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POWER

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By Their Works Ye Shall Know Them

"PRETTY good advertisement of your outfit and the way you use it," remarked the man who, attracted by the sign, stooped to see how much was ash and how much coal.

The fireman, hearty and good-natured, brawny and begrimed, saw the point and invited the stranger in. He beamed with justifiable pride on the whitewashed walls, the well-kept boiler fronts with their polished bright work, the cleanly swept floor, and the pile of "cinders," which was nothing but fine ash and clinker.

Then he showed his visitor the color of the fire through several peep holes in the side of the setting, explained understandingly the operation of the mechanical stoker which was feeding the fuel in with persistent regularity, and discussed intelligently the effect of different rates of feed of both coal and water, of different thicknesses of firebed, sizes of coal, different intensities of draft, etc. He did not refer to "calories" nor "B.t.u's," nor dally with chemical terms, but he knew what percentages of ash he got from different kinds of coal that he had used, and the efficiency of his plant on a basis of the steam made and the combustible fired.

There were no diplomas or certificates on the wall. The fireman did not boast membership in any union or lodge or society, nor wear any badges to indicate it, but that pile of ashes, his steam gage, and the top of his stack told conclusively that if a fireman is one who understands combustion then he has an unquestioned right to be known as such.

Power Plant of the Stanley Works

By Warren O. Rogers

Account of the development of the steam end of the works, from a 6-hp. engine to compound engines and a low-pressure turbine. The company was the first to install many of the modern steam plant appliances used in the city of New Britain, Conn.

The development of the power plant of the Stanley Works, New Britain, Conn., was largely pioneer work, as many parts of the equipment were the first of their kinds installed and operated in that city.

The original Stanley bolt works was built in 1832 by F. T. Stanley, who ran the first steam engine in that section of the country.

It was a small Burdon engine with a 6-in. cylinder and 24-in. stroke, and developed between 6 and 8 hp. This engine was operated until 15 years ago and is now set up and connected with steam in a room adjoining the main engine room, where it is preserved as a relic, Fig. 1. This was followed by a larger double, slide-valve Burdon engine.

Forty years later, or in 1872, a 125-hp. engine was installed and belted to the factory line shaft. The engine ran noncondensing until 1891, when a jet condenser was put in, the first used in the city.

The load increased and a 600-hp. cross-compound Corliss engine was installed, which was also the first in New Britain and is still in use. In 1905 a 24 and 44x42 in. compound engine was purchased, rated at 1200 hp., running at 120 r.p.m. It is directly connected to a 400-kw. direct-current 250-volt three-wire machine. It is also belt connected to a line of shafting.

In 1910 the first low-pressure steam turbine in the city was installed to run in connection with the large compound engine. The back pressure on the low-pressure cylinder is about 1½ lb. The turbine is connected to a Lablanc condenser which maintains a 28½-in. vacuum. The turbine is of 750 kw. capacity and runs at 1800 r.p.m. with a steam pressure of 150 lb. per square inch. The turbine is set on a concrete foundation, built separate from the building, as shown in Fig. 2. Its condenser is the only one of its type in the city, and, under a full load test run maintained 29 in. of vacuum.

The rated capacity of all generators is 1500 kw. or approximately 2000 hp., a gain in 40 years of 1994 hp.

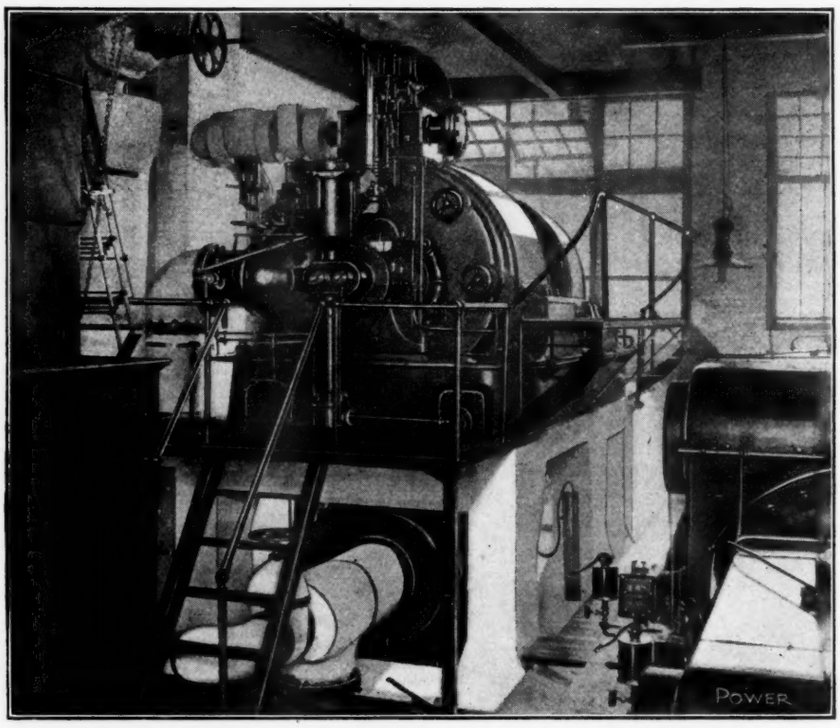

FIG. 2. EXHAUST STEAM TURBINE AND CONCRETE FOUNDATION

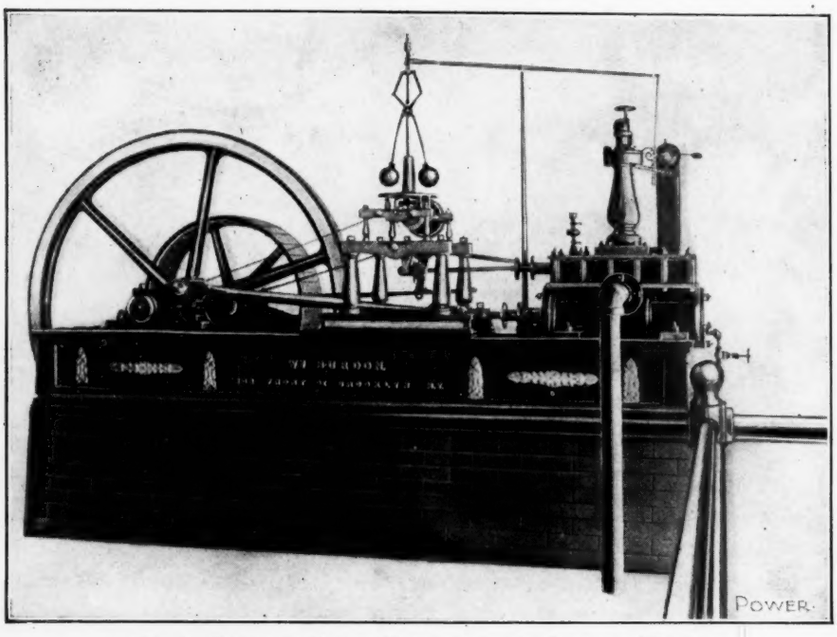

FIG. 1. ORIGINAL POWER ENGINE OF THE STANLEY WORKS

BOILER PLANT

The original plant consisted of Lowe boilers which were soon replaced by horizontal return-tubular boilers but in 1898 the first two water tube boilers used in New Britain were installed and two years later two more boilers of the same type, each having a rating of 338 hp., were put in.

The latter boilers had superheaters, again the first used in the city, and among the first made and used in this country. They are still in operation at the Stanley Works.

In the main boiler house four water-tube boilers are now installed, having a total capacity of 1352 hp.

Steam is carried from the boiler plant through a 600-ft. tunnel to the engine room. In this tunnel are all the steam and water pipes, and also the electric wires. It is said that the loss of steam due to condensation is less than 1 per cent.

The boiler furnaces have the first automatic stokers used in the city. A view of the boiler room is given in Fig. 3.

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Back of the boilers are the two fuel economizers. The new boiler house is on Curtis St., but two smaller boilers, one 250-hp. water-tube and one 125-hp. return-tubular boiler are in the small boiler house next to the engine room. This makes a total of over 1700 b.hp. capacity.

The only complete coal conveying system in New Britain is at the new boiler plant. Coal is delivered to an elevated siding so graded that the cars can be easily pushed along by hand and unloaded into a hopper under the track. The empty car is then run to the switchback and returned to a siding, as shown in Fig. 4.

The dumped coal falls into a crusher from which it is delivered to a continuous belt conveyor and carried from the hopper pit to the scale house where an automatic scale registers the amount of coal passing through it. The coal is then carried by a belt conveyor to the boiler-house coal bunkers. The fuel is fed through metal chutes to the hoppers supplying the stokers. Each coal chute is made in five sections, two pieces in the spout, three in the flare or mouth, one on top and two on the bottom. This permits removing any worn section without discarding the entire chute. The boiler plant is laid out for future duplicate units, outlets from the coal bin for which are provided as shown in Fig. 3.

The coal bin has a capacity of 420 tons. A reserve supply of 4000 tons can be stored in the yard. When storing coal, it is discharged from the first section of the conveyor onto the ground. It is then removed to the yard by a grab bucket, operated by a steam hoist.

When taken from the yard, the coal is picked up by the bucket and dumped into a hopper over the second section of the conveyor and carried to the coal bunkers above the boilers.

Ashes from the grate drop into a hopper below the boiler from which they are loaded into a small iron car, and hauled out and dumped on the ash pile. This ash car is drawn by a clutch-controlled winch, driven by the stoker engine and a bevel gear attached to the end of the stoker shaft. A second shaft with a winch and clutch attached to one end, is secured to the side of the boiler setting and a gear on the opposite end meshes with the stoker shaft gear. When ash is to be handled the clutch is thrown in and the ash car with its load is pulled up an incline to a 12-ft. level, from which the car runs by gravity to the end of the trestle. If the operator neglects to shut off the power, the link on the end of the cable will be automatically disengaged preventing damage to the driving gear or car.

FIG. 4. COAL CONVEYORS AND RUNBACK TRACKS

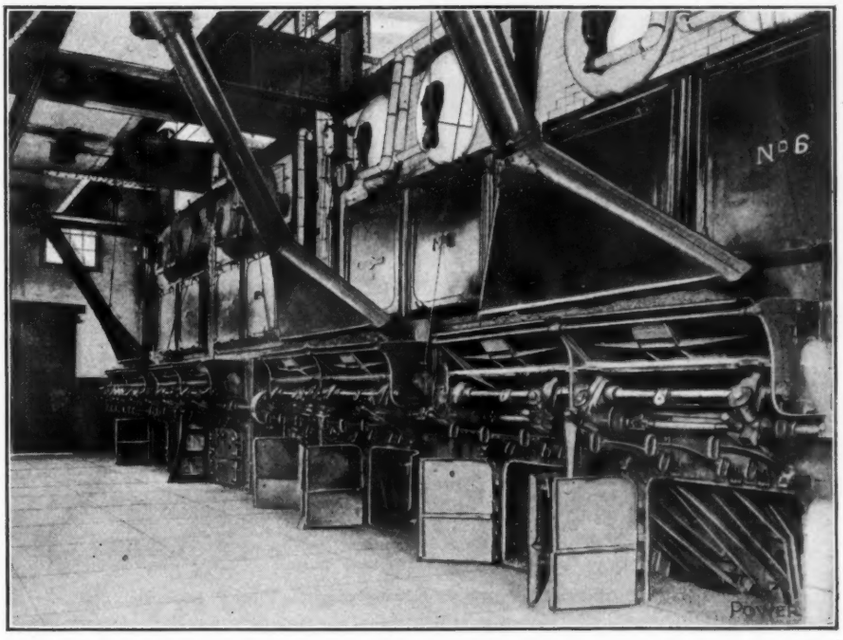


FIG. 3. BOILER ROOM OF THE STANLEY WORKS

Fig. 5 shows an appliance for grinding on the caps on the water-tube boilers. It was devised several years ago, by C. E. Hart, then in charge of the boiler plant and has since been patented by him. It bolts on the ends of two adjoining caps and can be put on either horizontally or vertically. It is a labor saver in grinding caps, and especially where they have been leaking and the seats have become somewhat pitted.

A universal joint just above the cap being ground gives the cap a proper fit on its seat, a perfectly ground joint resulting. A slight amount of powdered emery is used between the cap and the seat to facilitate the grinding.

FIG. 5. TUBE PLATE REGRINDING TOOL IN PLACE

SPRAY COOLING SYSTEM

The condensing water for the condensers is cooled by a number of jets, Fig. 6, which give the water a swirling motion, so that it falls to the surface of the pond in a fine spray. This reduces it to practically the same temperature as the atmosphere. It is the only spray-cooling system in New Britain.

FACTORY HEATING

In 1896 the Stanley Works discarded the old methods of steam factory heating and put in the first hot-water heating system in which the water was circulated by pumps. The water is heated by exhaust steam from the small engines, pumps and air compressors, and is handled by either one of two steam-turbine-driven

pumps installed in the boiler room, one of 30 and one of 60 hp. In extremely cold weather the exhaust from one of the reciprocating engines can be used to heat the circulating water in the heating system.

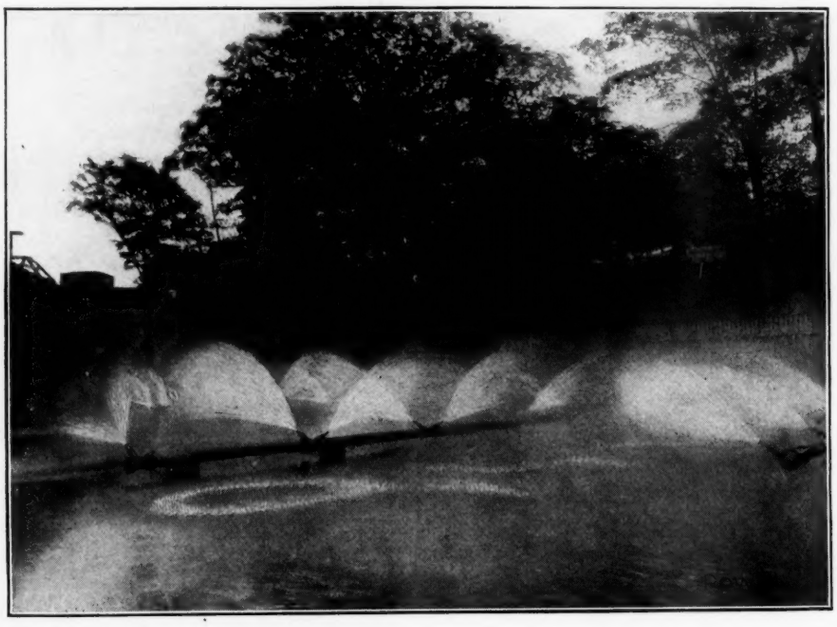


FIG. 6. SPRAY WATER COOLING POND

ELECTRICITY FOR SHOP USE

Up to 1870 electricity was not used at all in any of the city factories, but in this year an 18-arc-light machine was installed and was belted from the main shaft of the factory. In 1891-2 electric power transmission was installed at the works, which was not only the first electrical power transmission for factory use in the city, but was the first in Connecticut. Today practically every department is driven by electric motors.

In 1898 the Stanley company installed the first electric crane to be used in New Britain; there are now six at the works. In January, 1901, an electric locomotive was put in use on the industrial railway in the yard, and in 1903, electricity was still further used to operate electric elevators, also the first in the city.

From the foregoing, it is evident that, although the power plant as a whole is not as compact as might be desired, it comprises the most uptodate steam apparatus that can be purchased.

POWER PLANT EQUIPMENT OF THE STANLEY WORKS

No	Equipment	Make	Use	kw.	volts	R.p.m.	Size	Pressure Lt.	Hp.	Manufacturers
1	Simple engine	Burdon	Original unit	....	....	....	.....	....	6	Unknown
1	Cross compound engine	Frick	Main unit	....	....	75	6x14"	150	600	Frick Co.
1	Tandem compound engine	Rice & Sargent	Main unit	....	....	120	24x42x42	150	1200	Providence Engineering Co.
1	Simple engine	McEwin	Main unit	....	....	200	18x18	150	200	Ridgway Dynamo & Engine Co.
1	Steam turbine	Curtis	Main unit	....	....	1800	.....	150	1000	General Electric Co.
1	D. C. Generator	Ridgway	Main unit	200	250	200	.....	....	....	Ridgway Dynamo & Electric Co.
1	A. C. Generator	General Electric	Main unit	750	250	1800	.....	....	....	General Electric Co.
1	D. C. Generator	Westinghouse	Main unit belt driven	400	250	120	.....	....	....	Westinghouse Machine Co.
1	Condenser	Le-blanc	Turbine	....	....	....	.....	....	....	Westinghouse Machine Co.
1	Condenser	Blake	Reciprocating engine	....	....	....	.....	....	....	Blake Pump & Condenser Co.
23	Spray nozzles	Schutte & Koerting	Cooling water	....	....	....	3"	....	....	Schutte & Koerting
1	Steam pump	Worthington	Boiler feed	....	....	....	10x6x10	....	....	Henry R. Worthington
1	Steam pump	Worthington	Boiler feed	....	....	....	9x 6x10	....	....	Henry R. Worthington
4	Economizers	Green	Boilers and furnaces	....	....	....	.....	....	....	Green Fuel Economizer Co.
1	Regulator	XXth Century	Damper	....	....	....	.....	....	....	Atwood & Morrill
1	Co^2 recorder	Uehling	Flue gases	....	....	....	.....	....	....	Uehling Instrument Co.
1	Meter	Trident	Water	....	....	....	6"	....	....	Neptune Meter Co.
1	Filter		Oil	....	....	....	.....	....	....	Ross Valve Mfg. Co.
1	Meter	Arrow	Water	....	....	....	.....	....	....	Henry R. Worthington
2	Regulators	Crosby	Pumps	....	....	....	.....	....	....	Crosby Steam Gage & Valve Co.
4	Boilers	Babcock & Wilcox	Steam generators	....	....	....	.....	155	338	Babcock & Wilcox Co.
1	Boiler	Babcock & Wilcox	Steam generator	....	....	....	.....	....	250	Babcock & Wilcox Co.
1	Boiler	Return tubular	Steam generator	....	....	....	.....	....	125	

Figures regarding the operating cost are not available, but it is very probable that the power-plant cost is well below the average.

The author is indebted to E. W. Pelton, chief engineer, for data and photographs.

"Manners, like oil in the bearings of a machine, prevent friction and aid efficiency.

Pumping Coal

Following the transportation of oil in barrels and tank cars came the more efficient distribution by pipe lines. It is possible that coal may not only be taken out of the mines but transported to considerable distances in the same efficient way.

A movement is on foot in this direction. J. H. Hoadley and W. H. Knight have developed a system whereby the coal instead of being broken or blasted out of the seams in lumps is scraped off from the face of the workings in a granular state suitable for coking. Coal in this finely divided state and mixed with water can be pumped through pipe lines at a cost considerably less than that at which it can be transported by rail. Allowed to settle out of the water but still in a finely divided state, it can be blown into a furnace and burned under conditions of control which approach those of gaseous or liquid fuel.

The coal-mining machine consists of a rotary cutter adapted in diameter to the width of the seam. This is revolved by a direct-connected electric motor and is forced against the face of the seam hydraulically, being given at the same time a sidewise swing through a small angle so that the proper width may be cut. While the cutting is going on a stream of water is directed against the face of the seam, preventing the flying of the dust and keeping the tools in a cool condition.

The machines at present made have a capacity for cutting 100 to 250 tons per day. These will be followed by larger machines which are expected to raise the tonnage to 500. The mixed coal and water are driven by centrifugal pumps with one or more stages according to the lift required. Trials have been made of the machine at the Lewisburg mine in Alabama and it is said to have fulfilled the anticipations of its projectors.

Centrifugal Pumps for Condensers

By Richard L. Strobridge*

Characteristics and operating requirements of circulating, hotwell and tail pumps including a consideration of priming and sealing.

*Mechanical Engineer for Wheeler Condenser & Engineering Co., Carteret, N. J.

The design of a condensing equipment is in each case an individual engineering problem. This applies to the circulating pump, to the hotwell and tail pump, as well as to the condenser itself. The two most important elements to be considered in the design of the centrifugal pump are the capacity in gallons per minute and the dynamic head. The capacity is determined primarily by the size and design of the condenser, the vacuum and the temperature of water supply and the service the pump is to perform—that is, circulating pump, tail pump, or hotwell pump. For hotwell and tail pumps the head corresponds to 28 or 29 in. of vacuum plus any static head and friction head. For circulating pumps, the head is from 10 to 50 ft. and more (where a cooling tower is used), including the friction head lost in the condenser, which depends upon the length and number of passes, size of tubes and, as will be pointed out, the quantity of water being pumped.

Circulating Pumps for Surface Condensers

In a surface-condenser installation the circulating water is drawn from an intake well, canal, etc., through the suction pipe to the impeller of the centrifugal pump, whence it is discharged through the several banks of tubes and then through the discharge pipe to the sewer, discharge canal, or to the cooling tower. Where it is possible to seal the circulating-water discharge pipe, the system operates as a siphon, and the static head is the difference in elevation of intake and discharge canals. Where the discharge cannot be sealed, because of local conditions, the static head is equal to the difference of elevation of intake water and the top pass in the condenser. Where a cooling tower is used the static head is the difference between the elevation of the distributors at the top of the tower, and the suction of the pump. To this static head, in any case, must be added the head lost in friction, to obtain the total or dynamic head.

The head required to overcome friction varies as the square of the velocity of the water, and since for a given condenser the velocity of the water determines the quantity pumped, the head to overcome friction increases also as the square of that quantity. This can be best explained by reference to the curves of Figs. 1 and 2. The static head is 10 ft. and is constant regardless of the quantity pumped. For the rated capacity of the pump, 2500 gal. per min., the friction head with a certain condenser might be, say 15 ft., so that the total dynamic head is 25 ft. and the water horsepower 16. If it is desired to increase the quantity of circulating water to 4000 gal. per min. (with exactly the same condenser), the friction head becomes 43 ft., owing to the increased velocity of the water, the dynamic head 53, and the power 52.5, or over three times the power at rated load. Whether this expenditure of power would be profitable depends upon the design of the condenser, the influence of the increased velocity of the water on its efficiency and capacity and also on the type of prime mover, cost of coal and temperature of the water.

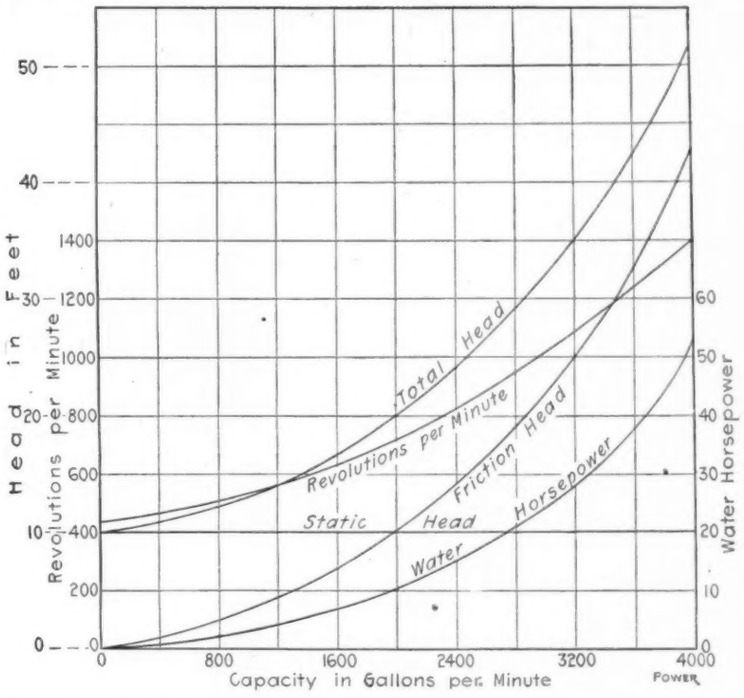


FIG. 1. EFFECT OF INCREASING VELOCITY OF CIRCULATING WATER ON POWER CONSUMPTION OF PUMP

The characteristic of a typical Wheeler circulating pump driven at rated speed is shown in Fig. 3. The sharpness with which the head falls off above rated capacity insures a drooping power curve and hence protects the driving machine from injurious overloads. Regulation of the discharge is obtained by adjusting a valve in the suction of the pump, where the velocity is low, and hence the head lost is slight.

This way of adjusting is usually adopted because provisions for speed regulation on the part of driving motors and turbines add to their complication, and require more expert attention from the operating force. With steam-turbine drive the exhaust is used in the feed heater, so that the loss, which in any case is small, is practically all regained and returned to the boiler as heat in the feed water. With engine or direct-current motor drive, the discharge is regulated by speed adjustment. The characteristics of a centrifugal circulating pump at different speeds is shown by Fig. 2.

Hotwell Pumps

Hotwell pumps must deliver water against the head corresponding to the vacuum, plus the friction head and the static head. The pump cannot create a suction sufficiently greater than the vacuum in the condenser to draw water into the impeller by its own action. Thus a static or gravity head is required to produce the entrance velocity and overcome the frictional and entry resistances to the flow of water from the bottom of the condenser into the impeller. Once the water is in the impeller it can be discharged against the pressure of the atmosphere and any static head imposed upon it, but it is essential that proper

provision be made for getting the water into the pump. With hotwell pumps and also with tail pumps, reliable service is insured by providing a suitable gravity head.

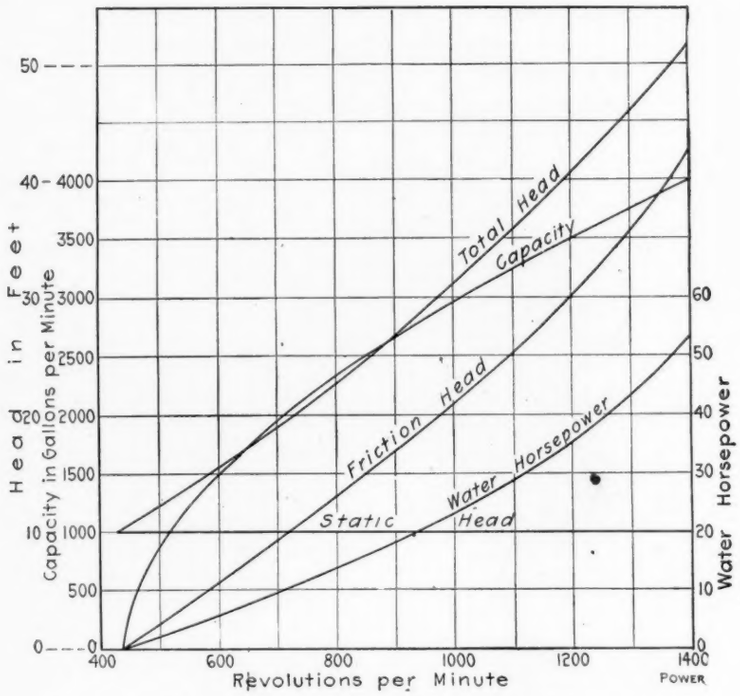


FIG. 2. RELATIONS BETWEEN R.P.M., CAPACITY, HEAD AND WATER HORSEPOWER

Hotwell pumps are built in single-stage and two-stage types. Typical designs are shown in Figs. 7 and 8. Two-stage pumps are sometimes used where the available gravity head is close to the minimum. Under these conditions the first-stage impeller helps to overcome entry losses and to increase the reliability of operation.

Fig. 4 is a head-capacity curve of a two-stage turbo hotwell pump of a maxi-

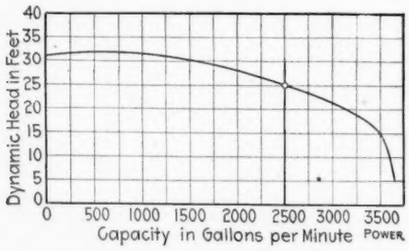


FIG. 3. HEAD CAPACITY CHARACTERISTIC OF CIRCULATING PUMP

mum capacity of 250,000 lb. of steam per hour. Hotwell pumps are rated at maximum capacity. A moment's consideration will show why this is the best method of rating. On heavy overloads the maximum output of the complete condensing equipment is not expected to be sufficient to maintain the rated vacuum. The vacuum is expected to fall off. The hotwell pump, however, is called upon to deliver the maximum quantity of water. Accordingly, a specific guarantee of the maximum capacity of the hotwell pump, and not the normal rating as with pumps for other services, should be demanded.

TAIL PUMPS FOR JET CONDENSER SERVICE

Fig. 5 gives the characteristic curve of a high-speed centrifugal tail pump for removing the condensed steam and cool-

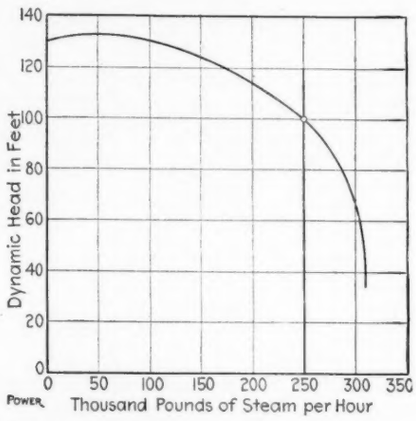


FIG. 4. HEAD CAPACITY CHARACTERISTIC OF HOTWELL PUMP

ing water from a jet condenser. This type of pump is used for rectangular counter-current jet condensers and under type jet condensers, taking the place of a barometric column. The discussion regarding the necessity of sufficient inlet gravity head for hotwell pumps applies with equal force to tail pumps. Reliable service can only be insured by providing ample gravity head.

The cooling water used by the jet condenser is controlled by throttling on the injection line to the condenser. The tail pump is usually run at constant speed, as is a hotwell pump, and delivers the combined cooling water and condensate against the pressure of the atmosphere and the static head.

For cooling tower work tail pumps have characteristics similar to that in Fig. 5, except that the head generated is higher throughout. Besides the head corresponding to the vacuum there is an additional static head depending on the type and design of the tower and its elevation.

Where a barometric jet condenser is used, the tail water is removed by the barometric column, but a pump must be employed to overcome the frictional head and the unbalanced static head against which the water supplied to the barometric cone must be pumped. Pumps for this service have a characteristic similar to that of Fig. 5, designed to deliver, when starting, a moderate quantity of water against full head, corresponding to the

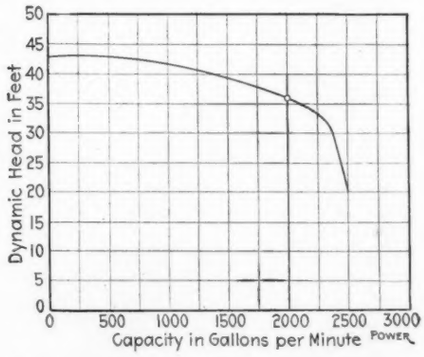


FIG. 5. HEAD CAPACITY CHARACTERISTIC OF TAIL PUMP

elevation of the barometric cone, and on full condenser load, greater capacities against a somewhat smaller head, since the vacuum in the condenser helps to lift the water.

PRIMING AND SEALING

Centrifugal circulating pumps for condenser service may be primed as are pumps for other services, that is, by a steam ejector creating a partial vacuum in the pump, and drawing up the water through the suction pipe, or, if a foot valve is used, by supplying water to the pump, either from a convenient water main or by an ejector. A circulating pump may be primed also by using the condenser and air pump to furnish the vacuum required to lift the water up into the pump. In surface condensers this system of priming necessitates a small bypass pipe from the water box into the condensing chamber proper, and after a vacuum is created in the condenser by the air pump, the valve in this small bypass is opened, thus transmitting the vacuum to the circulating water circuit, and to the centrifugal pump, so that

priming water is drawn up through the suction pipe into the impeller.

If the stuffing-boxes are in bad condition and air leaks into the pump, priming by this means or by the ejector creating a partial vacuum, will be very difficult. Sealing against the inleakage of air along the shaft of a centrifugal pump is also necessary because, if the pump is operating with a suction lift, air leaking into the impeller is likely to cause the pump to lose its water and to give trouble, due to air pockets.

Furthermore, with surface condensers, the system is often operated as a siphon, and if air leaks into the pump, it will collect in a pocket at the top of the siphon and eventually result in the pump losing its water. Where a centrifugal tail pump is used with a jet condenser, the stuffing-boxes must be tight, or the air leaking in will form a pocket in the pump and prevent the tail water getting into the impeller, which it must do by gravity. This also applies to hotwell pumps in connection with surface condensers.

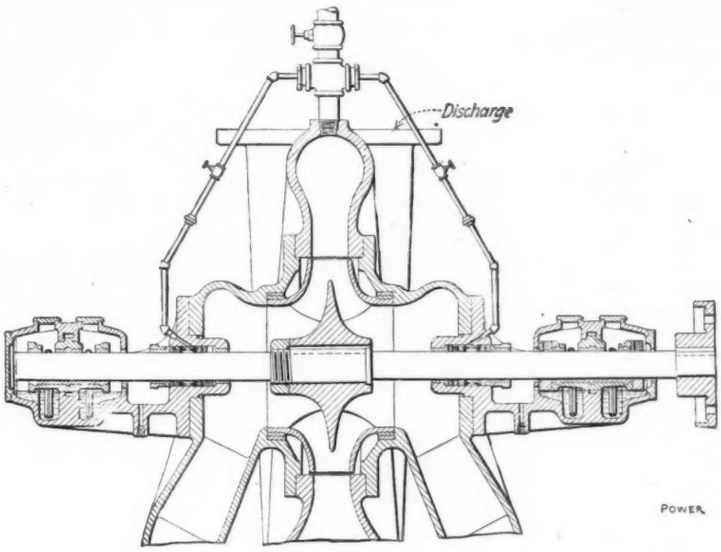


FIG. 6. SECTION OF CIRCULATING PUMP, SHOWING BEARINGS AND METHOD OF SEALING

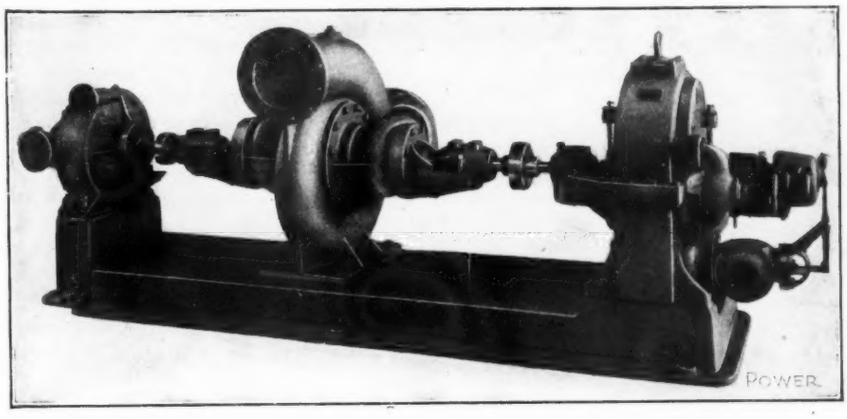


FIG. 7. CIRCULATING AND HOTWELL PUMPS ON COMMON BASE

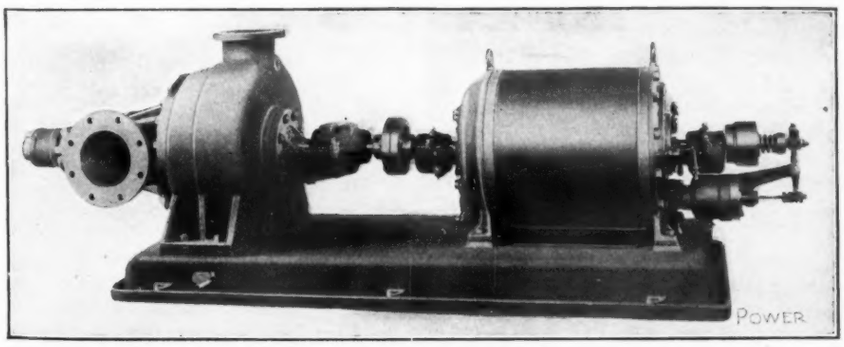


FIG. 8. TWO-STAGE HOTWELL PUMP

The design of stuffing-boxes used with Wheeler pumps is shown in Fig. 6. The stuffing-boxes are extra deep and take a large number of turns of packing, thus necessitating less pressure and eliminating binding of the shaft. Midway of the stuffing-box, that is, between the two packings, is a spacer or lantern, consisting of a bronze ring which receives the sealing water by the piping shown. No air can be drawn into the pump through the inner packing, since any leakage will only result in the introduction of sealing water continually supplied to the lantern, and the outer packing serves to prevent the leakage of this sealing water out along the shaft.

The Brotherhood of Power Workers

The Brotherhood of Power Workers is a commendable growing organization in Massachusetts. The following facts concerning it are from John A. Levy, of Greenfield, Mass:

The Brotherhood was organized in September, 1910, and those engaged in the generation and transmission of power regardless of race or color are eligible to membership. Its purpose is primarily to protect the plant worker by educating him to greater competency in his field. It does not interfere in labor disputes, except when a member asks for assistance in adjusting trouble. A committee is appointed for this purpose. It provides that no member shall fill a place left vacant by any organized worker through labor disputes.

The Brotherhood takes the stand that a cheap man in the plant is far worse than cheap material and supplies. Through its employment bureau, it aims to offer high-grade service, combined with coöperation with employers to obliterate friction between employer and employee. An examining board questions and coaches an applicant desirous of obtaining a license. A sick and accident benefit of $5 per week is allowed, and a death benefit of $1 from every member, granted to beneficiaries of a deceased member. It is proposed to establish an insurance department to assist in maintaining and providing the death and sick benefits. The initiation fee to the Brotherhood is $3, one of which goes into the death-benefit fund. The dues are 50c. a month. Additional information may be obtained from the corresponding secretary,, C. C. Harris, 89 Hall St., Springfield, Mass.

We extend our best wishes to the Brotherhood for a long and prosperous life and the realization of its aims.

Some Common Thermometer Errors

By J. C. Peebles

Mercury thermometers are subject to errors which often are overlooked. This article indicates where these are likely to be found and how they may be avoided or corrected.

While the ordinary glass thermometer filled with mercury is the instrument in most general use for the measurement of temperature, the experience of the writer in the use of many of them has been that they are oftentimes subject to very serious errors which the average user fails to detect or to take into consideration. The very simplicity of the instrument makes it easy for these errors to pass unnoticed, and it is the purpose here to point out to the average user just where these errors come in, and to indicate how they may be avoided or reduced in magnitude.

Error Due to Distillation of Mercury

When the ordinary thermometer is used above a temperature of 200 deg. F., a more or less rapid distillation of the mercury takes place. If the upper part of the stem is cool, this mercury vapor condenses in the upper part of the capillary tube and remains there. After a prolonged period of heating at a temperature of 200 to 300 deg. F., it is no uncommon experience to find a thread of mercury several degrees in length in the upper part of the capillary tube. Obviously this introduces an error into the indication of the instrument. For example, if a thread of mercury 5 deg. in length has collected in the upper part of the tube, the thermometer indications will be 5 deg. low.

Up to about 400 deg. this distillation and subsequent condensation of the mercury can usually be avoided by keeping the top of the mercury column cool or the whole stem warm. The former prevents distillation from the surface of the mercury and the latter the condensation of the mercury vapor in the top of the tube. It is believed that most users will find it easier to keep the top of the mercury column cool by allowing the stem to project far enough out of the hot body so that the top of the mercury is at a comparatively low temperature, say 200 deg. or less. If the nature of the work makes this impossible, the whole thermometer must be kept warm.

Above 400 deg., these precautions will be found inadequate. In the manufacture of the better grade of thermometers intended for high-temperature work, the capillary tube above the mercury is filled with an inert gas, usually nitrogen. As the mercury rises in the tube the nitrogen is compressed into smaller volume and the increase in pressure prevents the boiling of the mercury. When purchasing a thermometer to be used above 400 deg., where reliable results are essential, a nitrogen-filled instrument should be specified.

Error Due to Shrinkage of Glass

After a thermometer has been made, filled with mercury, and the scale etched on, it may undergo changes which very seriously affect its accuracy. These changes are caused by a gradual adjustment of the internal stresses in the glass which were produced when the stem was made. As these stresses are relieved by the aging of the glass, contraction of both stem and bulb takes place, thus rendering all the readings high. This slow contraction may continue for months, and even for years, before all the glass stresses are relieved. Thus, if it has been made from "green" or unseasoned glass it will show an increasing error as time passes.

The only remedy for such a condition is to season or age the thermometer before the scale is put on by a process of annealing. This is done by subjecting it for a period of four to seven days to a temperature somewhat above the highest at which it is to be used, followed by slow cooling for two to three days. The artificial aging removes all the internal stresses in the glass and leaves it in a condition of equilibrium where no further contraction of stem or bulb can occur.

Experiments conducted by the writer on unannealed instruments showed that an error of 40 deg. in 600 deg. F. was not unusual. Errors of 60 deg. in 750 deg. were found in several cases, while errors of 25 deg. in the range from 400 to 700 deg. were common. As many thermometers in the market have not been properly annealed, it must be kept in mind that their indications, particularly in the foregoing range, are capable of very serious error and should at all times be regarded with suspicion. When reliable results are required, only a well annealed instrument, from a reliable maker, should be used.

Error Due to Partial Immersion

When a thermometer has been properly annealed in the making, and has been filled with nitrogen to prevent boiling the mercury, its indications may still be subject to errors depending upon the conditions under which it is used. Thermometers are calibrated under a condition of "total immersion"; that is, the entire instrument is brought to the desired temperature when the fixed points of the scale are located. Therefore, the indications are correct only under a condition of total immersion. But in its ordinary use a condition of total immersion is very seldom realized.

The usual condition is to have the bulb and a short length of the stem immersed in the hot medium while the remainder projects into the air at a much lower temperature. A considerable length of mercury in the capillary tube is thus at a much lower temperature than that in the bulb; this causes the thermometer to read lower than if the entire instrument were at the same temperature. This "stem correction," as it is called, will depend upon the difference in temperature between the immersed and emergent parts, the length of the emergent part and the glass of which the thermometer is made. In many cases the magnitude of this stem correction is such as to interest every user, the practical as well as the purely scientific man.

The determination of the flash or burning point of an oil is a test which any operating engineer may wish to perform, and the experience of the writer may be of interest in this connection. Some heavy cylinder oil was placed in a copper cup and heated electrically. The thermometer used had a scale running from 150 to 800 deg. F., and was immersed to the 200 deg. point in the oil. The burning point was ascertained to be 625 deg., as shown by the thermometer. A calibrated platinum resistance thermometer, which is compensated for depth of immersion, read 652 deg. F. when placed side by side with the glass instrument, which was therefore 27 deg. low at 652 deg., the latter being the correct burning point of the oil. As a further precaution to insure reliable results, the two thermometers were placed side by side in an oven, which gave a condition of total immersion for the glass one. At 650 deg. their readings were substantially the same.

Formula for Correcting Error Due to Partial Immersion

This stem correction may be determined from the equation

$$S = K n (T_1 - T_2)$$

where

S = Stem correction in degrees;
n = Number of degrees that mercury emerges from hot body;
T_1 = Temperature of hot body;
T_2 = Average temperature of emergent stem;

K = A constant depending on the glass of the thermometer.

In the above experiment

$S = 27$ deg.;

$n = (625 - 200) = 425$ deg.;

$T_1 = 625$ deg.;

$T_2 = 150$ deg.

whence

$$K = \frac{27}{425\ (625 - 150)} = \frac{27}{425 \times 475} = 0.0001337$$

For this thermometer, then, the equation

$$S = 0.0001337 \times n\ (T_1 - T_2)$$

will give the stem correction for any condition of partial immersion.

Summary

When working in the range from 300 to 700 deg. F. the average thermometer user should keep in mind the following points: (1) Do not allow the mercury to distill and condense later in the top of the tube; better still, use a nitrogen-filled thermometer. (2) For careful work use only one which is known to have been well annealed in the making. (3) Ascertain the stem correction, for it may frequently introduce an error as large as 5 per cent. If a standard thermometer is not available for this determination, any reliable testing bureau will do the work for a very nominal charge.

The 1912 U. S. Standard

The *Journal* of the American Society of Mechanical Engineers comments upon the flange situation as follows:

The various makes of flanges and fittings now on the market, figured on the basis of the bolt stress, show a factor of safety in many cases as low as two and in a few cases even less. This compared with the necessary factor of safety of the pipe itself which is approximately sixteen, shows at a glance the necessity for the changes made in the 1912 U. S. Standard, of bringing up the factor of safety in the bolts, flanges and fittings, especially in view of the enormous strains encountered due to changes of temperature.

The other important feature in the 1912 U. S. Standard is the uniformity of dimensions providing for interchangeability of fittings. Until very recently, each manufacturer had his own standard and chaos has resulted, so that the engineer must know what particular make is to be purchased before he can proceed to design or erect the piping work. Hereafter all fittings of all manufacturers who comply with the new schedule will be uniform in the principal dimensions, and this will be an important factor in obtaining quickly spare parts throughout the country and enable one readily to make repairs and alterations. The new standard does not attempt to fix the quality of the metal or the thickness of the shell of fittings, leaving this to the manufacturers to regulate in accordance with their guarantee, depending on the pressure the fittings are to carry.

Standard Weight Flanges

In comparing the 1912 U. S. Schedule of Standard Weight Flanges with the alternative standard submitted by the subcommittee of manufacturers with respect to diameter of bolt circle, number of bolts and diameter of bolt-holes, we find they are identical, with the one exception that the U. S. Standard gives ⅞ in. instead of ¾ in. for diameter of bolt-hole for 4-in. pipe.

The standard of the Engineering Standards Committee of Great Britain and the standard of the Verein deutscher Ingenieure do not have sizes exactly corresponding to the standard weight and extra-heavy weight of the 1912 U. S. Standard, but have the most important dimensions, the same for all pressures, making their piping on low pressures unnecessarily heavy and expensive, but without securing absolute safety for high pressures. Comparing the proposed Manufacturers' Standard with British standard pipe flanges for working steam pressures of 225 lb. per sq.in., we find the British standards give higher values, especially as far as number of bolts is concerned.

Extra-heavy Flanges

For extra-heavy flanges up to 9 in. inclusive, the 1912 U. S. Standard and the standard of most manufacturers are identical. Above 9 in. the U. S. Standard is somewhat larger than the present standards, as has been stated. With the British standard, the diameter of bolt circle and number of bolts are the same for pipes corresponding to the 1912 U. S. Standard or proposed Manufacturers' Standard weight and extra-heavy weight, but from 10 in. on the diameter of the bolt circle is from ¼ to ½ in. less than the proposed Manufacturers' Standard and ¾ in. less than the U. S. Standard. The number of bolts in most cases for pipes from 10 in. on in the U. S. 1912 and Manufacturers' is from two to four bolts greater than in the British standard. As far as size of bolts is concerned, the British standard makes a distinction between pipes for pressures up to 225 lb. and up to 325 lb. The bolts for pipes up to 225 lb. are below the Manufacturers' Standard ⅛ in. in nearly every case and below the U. S. Standard from ⅛ to ⅜ in. In pipes for pressure of 325 lb. the British standard is the same as the proposed Manufacturers' schedule in all cases except 14 in. and 18 in. where the British standard is ⅛ in. larger than the Manufacturers' standard, but from ⅛ to ¼ in. smaller than the U. S. standard.

It is thus seen that wherever there is a distinction between the 1912 U. S. and proposed Manufacturers' Standard, the 1912 U. S. Standard is invariably on the side of greater safety and strength and has the added feature of interchangeability where the proposed Manufacturers' schedule has different face to face dimensions. As to the comparison with the British and German standards it must be remembered that they cover by one standard both weights of the American specifications, and as would be naturally expected with compromises must have higher values for standard weight pipes and lower values for extra-heavy weight pipes. However, in Germany there is reported in the public press dissatisfaction with the existing standards as not being safe. The Alsace Association of Owners of Steam Machinery prints in its annual report for 1911 as follows:

"It is nearly impossible to estimate with any degree of precision the bending stresses to which pipe flanges are submitted when, to obtain a good joint, the bolts are screwed tightly, especially if the flange has to withstand at the same time stresses due to expansion. As a result, many of the joints in pipes and similar apparatus are working with very low factors of safety, as has been shown lately by the fact that accidents from piping have been far more numerous than from boilers, and with as fatal consequences."

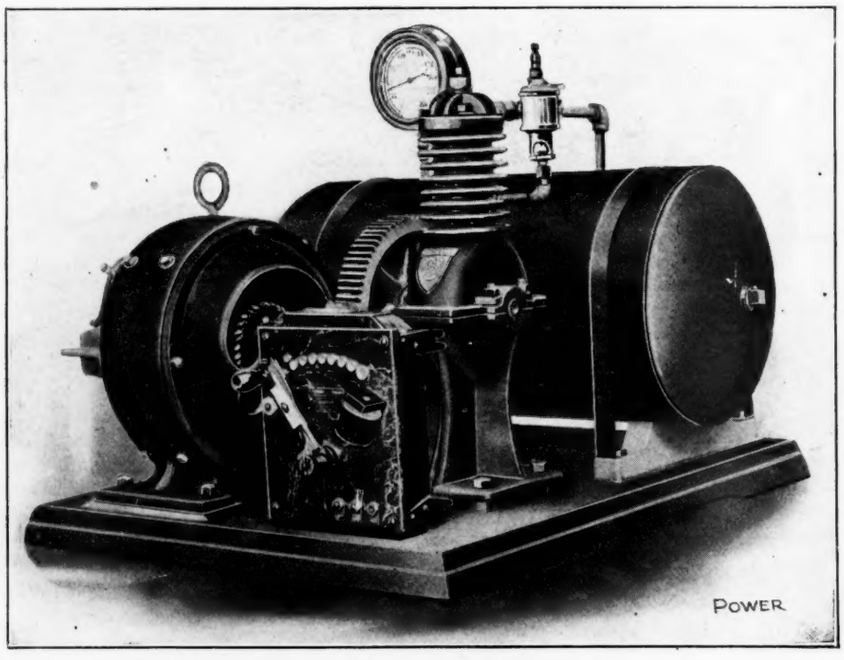
The 1912 U. S. Standard is the result of the efforts of the aforementioned committees covering a period of over a year during which time every detail was considered. The committee had the active coöperation of engineers representing large power plants, manufacturers and the U. S. Navy Department. Prominent engineers and architects throughout the country were communicated with and their opinions and advice received and considered, and the consummation is the 1912 U. S. Standard.

The first impulse turbines had blading in which the inlet and discharge angles were equal. Now almost all builders use blading of which the discharge side of the blade makes a sharper angle with the axis than the inlet side. This does not necessarily mean that the discharge area of the blades is smaller than the inlet area, for the blade is usually lengthened radially on the discharge side. Thus both inlet and discharge areas are made equal. The sharp angle of discharge reduces slightly the relative velocity of exhaust from the moving blade. In turbines of the Curtis type there is usually only a small difference between the inlet and outlet angles of the first row of moving blades, but on the second row of moving blades in the stage the entrance and exit angles often differ by as much as 15 deg.—*The Engineer.*

The 12-gun battleship "Wyoming" has a cruising speed of over 22 knots an hour.

Goulds Air Compressor Outfit

The Goulds Manufacturing Co., Seneca Falls, N. Y., has placed on the market a complete air-compressor outfit, consisting of an air-compressor pump mounted on an iron base with the driving motor, starter, and air-storage tank. The motor has an output of 1 hp. and the pump has a capacity of 1.27 cu.ft. of free air per minute when operated at 150 r.p.m. The outfit is compact and self-contained. With a tank 28x14 in. in diameter, with a capacity of 3¼ cu.ft. of air at 150 lb. pressure, the overall dimensions of the base are 30x30 in. Tanks of larger or smaller capacity are furnished as desired.



GOULDS MOTOR-DRIVEN AIR-COMPRESSING OUTFIT

Stop Valves in Boiler Piping

The location of stop valves frequently turns an otherwise excellent piece of boiler piping into a rank failure, and often produces a menace to life and limb. Fig. 1 shows the usual construction adopted for connecting a boiler to a steam header. Such a method is excellent with the exception of the location of the stop valve, which is the one most frequently chosen, apparently because it can be most easily reached from the top of the boiler, when so located.

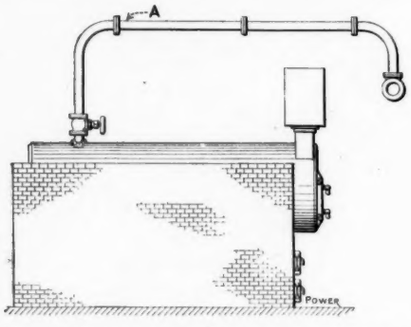


FIG. 1. BOILER AND HEADER CONNECTION

With the valve placed as shown, a large quantity of water can collect above it when it is closed; this is a source of great danger when cutting a boiler in on the line. Of course, a bleeder can be connected above the valve, but sooner or later someone in a hurry, or forgetful, will open the main valve without draining the pipe, with probably disastrous results. If the pipe pitches from the main header to the boiler, water will lie along the horizontal section when the valve is closed, thus producing trouble at the joints by leakage.

The correct location of a valve on this type of connection is at *A*, with the pipe pitching from *A* toward the steam main.

To have a stop valve accessible is a very important consideration. This should be accomplished by providing chains so that the valve may be handled from the boiler-room floor. A stop valve should always be located where it will prevent the accumulation of water, accessibility being a secondary consideration.

In Fig. 2 is shown an arrangement of piping and valves that appears excellent, but it developed a serious objection when put under steam pressure. The connections from the main header to the individual boilers, which were about 40 ft. long, were made of 6-in. pipes, using long-radius bends where connections were made to the boilers. With the valves located as shown, there was no chance for water pockets as the pipes drained back to the boilers. However, when one of the boilers was idle and its stop valve was closed, the connecting pipe would cool off to the temperature of the atmosphere, which at 60 deg. F. made it about $\frac{15}{16}$ in. shorter than the other two at a temperature corresponding to the running pressure of 125 lb.

Owing to the rigidity of the 12-in. header, this change in pipe length was practically all accommodated by the giving of the pipe at the end where it was attached to the boiler. Joint trouble resulted almost immediately, and after about three years' use the pipes began breaking at the flanges where connected to the boilers due to the excessive strain and the vibration of the pipe.

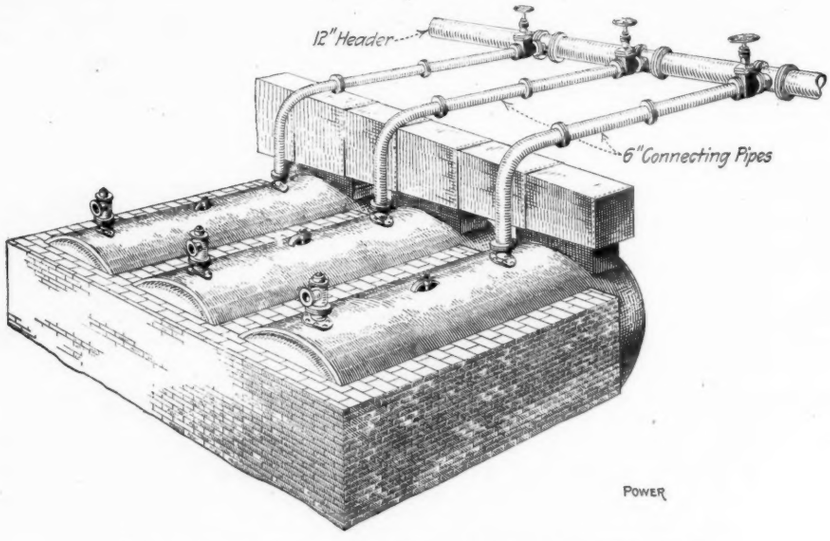


FIG. 2. LOCATION OF STOP VALVE IN HEADER CONNECTION

The proper location for the stop valves was, of course, near the connection to the boilers; then all of the piping beyond them would have always remained at a uniform temperature.

Threshing Machine Boiler Explosion

By E. H. Kirchner

At 8:30 a.m., Aug. 28, a 20-hp. threshing-engine boiler exploded, killing the engineer in charge; a 16-year old boy was badly scalded, but there are hopes of his recovery.

The outfit was in service a short time the day before. In the morning the boiler was fired up by the owner until 120 lb. of steam was registered with two gages of water showing. The engineer was on the foot-board just starting the engine when the explosion took place. The boy was blown about 200 ft. The firebox and rear truck were thrown back about 15 ft., pinning the engineer under the heavy mass, and killing him instantly. Figs. 1 and 2 show the result of the explosion.

The front truck was thrown about 10 ft. forward and 5 ft. to the right. The boiler, as indications show, ruptured at the seam where it was riveted to the firebox.

The sheet was nearly straightened out. It was patched about two years ago and was bagged. This piece practically contained the whole boiler sheet which sheared off 2 ft. from the front end and at the back where it was riveted to the firebox. It weighed about 450 lb. and was blown into the air about 100 ft., dropping through the roof of a barn.

The boiler tubes were bent and twisted and driven into the ground. The shell was not crystallized and did not show low-water indications. The shell was ¼ in. and the head ⅜ in. thick, but in places the shell was pitted badly, leaving only about ⅛ in. thickness.

The flues looked good and if there was any scale on them it was blown off when the explosion occurred. The rivets in the bottom of the girth seam pulled through the rivet holes nearly half around the boiler; the balance of the shell was torn and ripped open lengthwise. The boiler was about 12 years old, but had been rebuilt.

Test of Line Shaft Bearings

By W. C. DuComb, Jr.

The following results were obtained from comparative friction tests of line-shaft bearings recently made under the direction of S. A. Ellicson, president of the Chicago Pulley & Shafting Co. The object of the tests was to determine just how much less friction is found in correctly designed roller bearings operating under normal conditions of line-shaft service than in ring-oiling babbitt bearings operated under similar conditions.

A testing device specially designed for the purpose was set up with means provided whereby a known load could be applied to the bearings under test, and the friction load accurately measured. The friction was electrically measured by the testing device.

The tests with stock bearings were made as follows: The motor was first run light to find the power required to turn it over, the ammeter indicating 0.775 amp. The belt was then placed on the motor pulley and on the pulley on the shaft supported by two ring-oiled babbitt bearings. A load equivalent to 1200 lb. was applied by the lever and weight, thus imposing a load of 600 lb. on each shaft or 300 lb. on each bearing tested.

The motor was started by moving the lever on the starting box over slowly, and after the first high reading, due to starting the shaft, the amperage gradually dropped until 1.4 amp. was indicated. The difference between 1.4 and 0.775 amp. or 0.625 amp. required to run the motor is taken as the power loss in the bearings.

The belt was then moved to the shaft pulley supported by two roller bearings and the same load applied. The pointer settled at 1.15 amp. The difference between 1.15 amp. and 0.775 is 0.375 amp., which is taken as the power loss in the two roller bearings. This makes a difference of 0.25 amp. in favor of the roller bearings or $^1/_{7}$ hp.

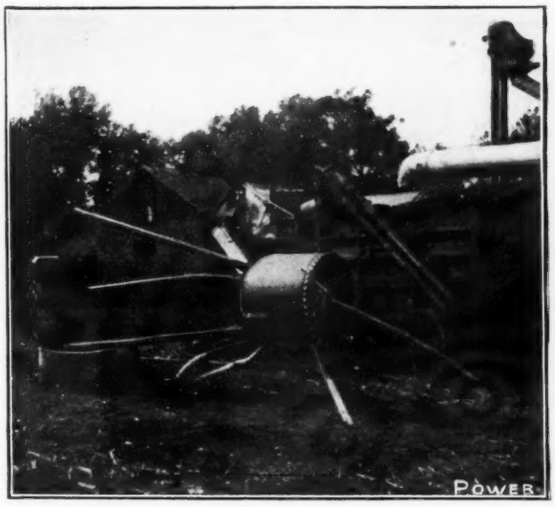
A high-grade machine oil was used for the ring bearings, and a nonfluid oil was used on the roller bearings. Oil was also tried in the roller bearings and practically the same results obtained. The only difference observed being that slightly less effort was required to start the shaft when oil was used.

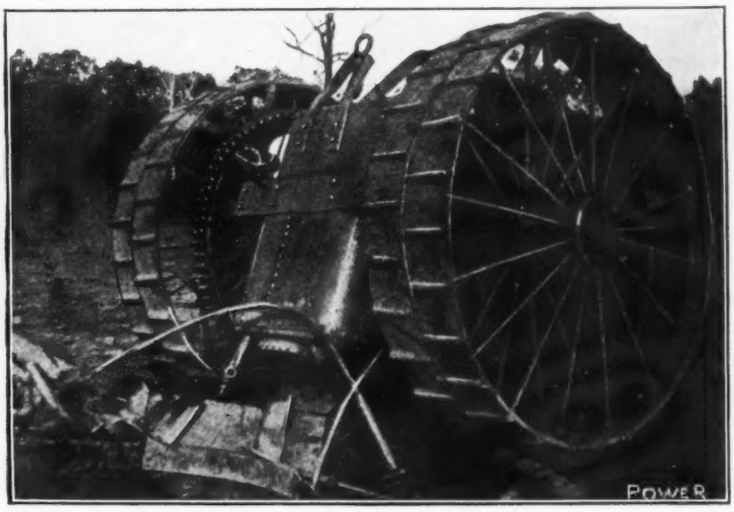
Swain Metallic Packing

In the line of metallic packing, manufactured by the Swain Lubricator Co., 328 West Lake St., Chicago, Ill., is an improved piston-rod packing for heavy service. The wearing rings are made with angles of 30 and 60 deg. to make efficient contact joints. The rings come in two sections each and are faced with bronze; one section overlaps the other and each is doweled to keep it in position and form a tight joint.

Another design is called the double or compound packing. The rings retain any condensation that may escape past the primary wearing rings and thus keep the external engine parts dry. The wearing rings are made from a special babbitt encased in bronze, and suited to the conditions under which they are to be used.

There is also a rotary valve-stem packing for use with Corliss engines. The outer parts rotate with the valve stem, the advantage being the elimination of wear on the stems. The operating joints come next on the valve stem. These joints are lubricated with oil supplied through a feed pipe. The tension of a spring is just sufficient to prevent leakage past the valve stem. The packing is used with superheated steam.





Figs. 1 and 2. Remains of the Exploded Boiler

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

The Single Phase Commutator Motor

By John A. Randolph

The extensive application following the recent development of the single-phase commutator motor, has led many engineers to study the design and operation of this type. As a result, many modifications have been produced, each with its own particular merits. However, after the test of service, many of these have been compelled, on account of commutation difficulties and low efficiency, to give way to a few styles which have proved practical.

The investigation in detail of alternating-current phenomena is more or less complex in that it requires the extensive use of mathematical equations and vector diagrams together with exhaustive experimentation; hence the task of those who have brought forth successful single-phase series motors has been by no means light. To enter a detailed mathematical discussion of the various successful types is not within the scope of this article, but rather it is the purpose to set forth the principles involved and to give a general explanation of the methods of design most commonly employed.

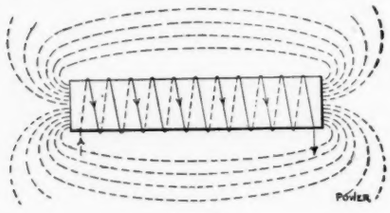


FIG. 1

FIG. 2

It is well known that if both the armature and field connections of a direct-current motor are reversed, the direction of rotation is not changed. It therefore follows that the same result will ensue when an alternating current is applied to these terminals. However, while a direct-current motor can be made to turn on an alternating current, many difficulties are encountered which render it wholly unsuited for such work unless especially designed for operation on an alternating-current circuit.

One of the chief difficulties is the heavy loss caused by the eddy currents produced in the field cores by the alternating flux, a loss which must be considered very carefully in the design of all alternating-current apparatus employing iron cores in the magnetic circuit. The means employed for its reduction consists in laminating the core, the field frames and poles being laminated in the alternating current motor instead of solid iron, as in the direct-current motor.

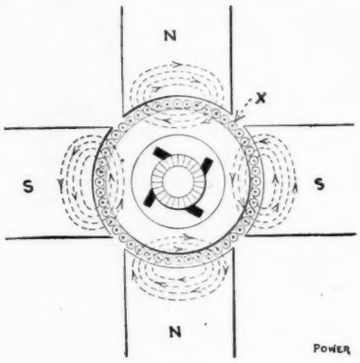


FIG. 3

Another obstacle is the short-circuit current flowing in the coils undergoing commutation, an action analogous to short-circuiting the secondary of a transformer. In the motor, the field winding acts as the transformer primary and the armature coil, undergoing commutation, as the short-circuited secondary. With a strong flux and a high frequency, this current will be comparatively large, causing a local I^2R or heat loss of considerable magnitude and heavy sparking as the coil passes from under the short-circuiting brush. To obviate this, several means are employed. One consists in greatly reducing the flux by increasing the number of ampere-turns on the armature and decreasing those on the field. The density is further reduced by spreading the flux more broadly over the armature, the number of field poles being increased to accomplish this purpose. This accounts in part for the greater number of field poles in the alternating-current motor and also for the larger armature than is customary for direct-current motors of the same output. This feature, combined with the laminated construction of the field frame, makes the weight of the alternating-current motor, in general, from 30 to 50 per cent. greater.

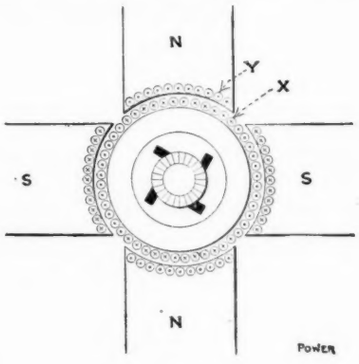


FIG. 4

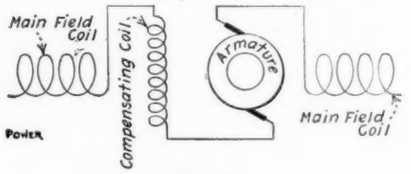


FIG. 5

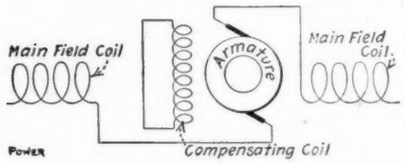


FIG. 6

A feature always to be considered in connection with alternating-current work is the electromotive force of self-induction which exists in a coil through which the current is rapidly alternating. In the motor, this force causes the current to lag behind the impressed voltage thus lowering the power factor and consequently the efficiency of the motor. It is chiefly for this reason that the shunt motor is not adapted for alternating-current work, owing to the great number of its field ampere-turns and the consequent high inductance. In the series motor, the current in the field is always in phase with that in the armature and the inductance of its field is much less than that

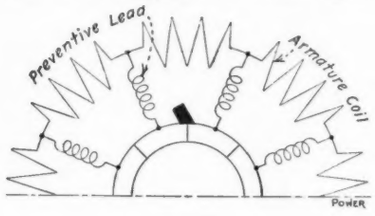


FIG. 7

of the shunt type; therefore this is generally used for a single-phase commutator type. Nevertheless, in the series motor, considerable self-induction still exists which must be overcome. Inasmuch as this force opposes the flow of current set up by the impressed voltage, part of the latter must be expended in

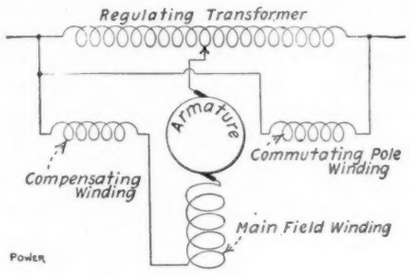


FIG. 8

overcoming it; hence the applied voltage must be greater than that for a similar direct-current machine. Another difficulty which may occur as a result of the self-induction is the accidental short-circuiting of one or more field coils. When this occurs, the coils at once act as the short-circuited secondary of a transformer, thus causing a heavy flow of current which is liable to burn out the insulation of the affected coils unless detected in time. Great care is therefore necessary in the design of the coils.

The electromotive force of self-induction is directly proportional to the frequency of the supply voltage, to the field

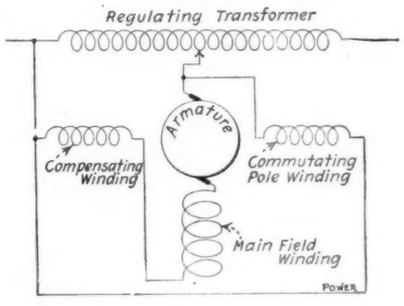


FIG. 9

flux and to the square of the number of its turns; therefore, in the design of an alternating-current series motor, these points should all be considered in order that the power factor may be as high as possible. The frequency can be made as low as commercial practice will permit, but it cannot well be lower without special generating apparatus. By increasing the number of armature coils and conductors and decreasing the field strength, the inductance of the field is greatly reduced, but the cross-field of the armature is increased.

The cross-field should be carefully considered in the design of all commutating machines whether built for direct or alternating current. Its tendency to distort the main field flux and thus to greatly increase the commutation difficulties is well known. In alternating-current series motors it is counteracted by compensating coils, in explanation of which consider a simple coil of wire wound upon an iron core, as in Fig. 1. If a current is passed through this coil, a magnetic flux will be induced as indicated, its intensity being greatly increased by the presence of the iron core. Now let a second coil containing the same number of turns, be run parallel to the first coil, as in Fig. 2.

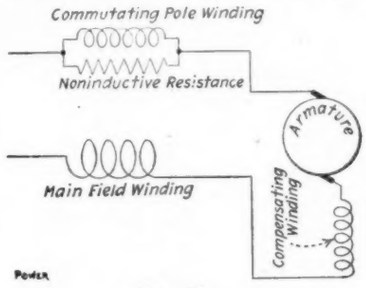


FIG. 10

If a current is passed through the second coil of the same strength as that in the first coil, but in the opposite direction, the magnetic induction of the first coil will be counteracted so that practically no flux will flow through the iron core.

Now modify Fig. 1 as in Fig. 3 and

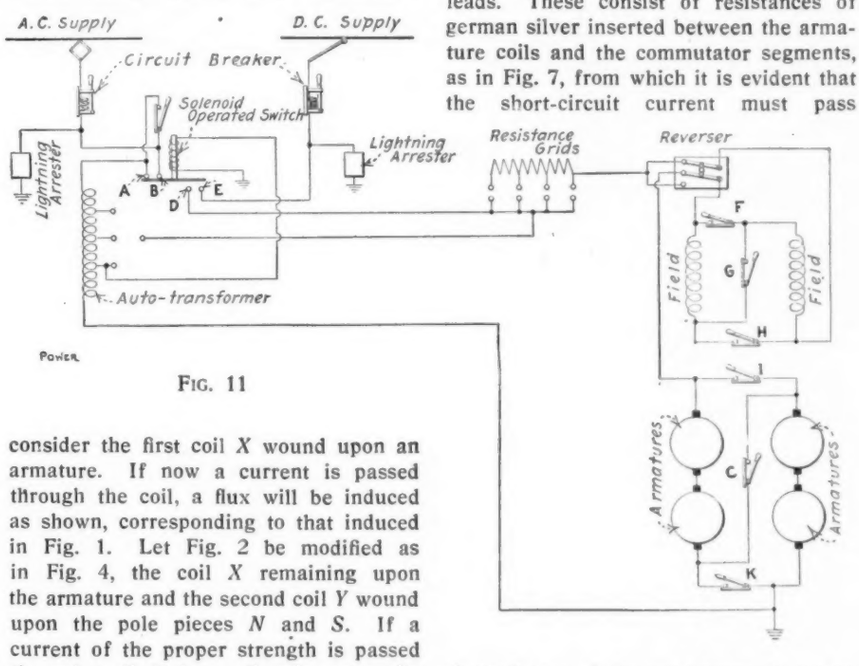


FIG. 11

consider the first coil *X* wound upon an armature. If now a current is passed through the coil, a flux will be induced as shown, corresponding to that induced in Fig. 1. Let Fig. 2 be modified as in Fig. 4, the coil *X* remaining upon the armature and the second coil *Y* wound upon the pole pieces *N* and *S*. If a current of the proper strength is passed through coil *Y* in a direction opposite to that in coil *X*, the magnetomotive force setting up the flux shown in Fig. 3 is neutralized, and the flux disappears. This flux thus compensated is the element which would cause field distortion if allowed to exist.

This principle is utilized in designing a single-phase commutator motor. The armature is surrounded by a fixed winding carried in slots cut in the pole pieces, this winding being so designed that its current will be equal in magnetomotive force and opposite in phase to the current in the armature, thus neutralizing the distorting effect of the cross-field set up by the latter. A common method of supplying current to the compensating winding consists in connecting the coil in series with both field and armature as in Fig. 5. This is known as the forced compensation or conductive method.

Another method consists in short-circuiting the coil upon itself, as in Fig. 6. In this the current is induced in the compensating winding, acting as the short-circuited secondary of a transformer of which the armature is the primary.

A serious obstacle encountered in alternating-current commutator motors is the current generated in the coils undergoing commutation. When the coils are short-circuited at the commutating point by the brushes bridging over the commutator segments, a large current will flow through the coil, owing to the action of the alternating flux. Unless effective means are employed to reduce this current, it will seriously decrease the efficiency of the motor and shorten its life, owing to its heating effect and its tendency to produce heavy sparking at the brushes. To overcome this difficulty several means are employed. One of the most common is the use of preventive leads. These consist of resistances of german silver inserted between the armature coils and the commutator segments, as in Fig. 7, from which it is evident that the short-circuit current must pass through two of the resistances in series, thus being greatly reduced. In considering this feature, the question may arise as to whether this means offers material advantage as the useful current must also pass through these leads before it reaches the coil. It is true that a small loss occurs on this account, but as the effective current, after entering the first coil, passes through a number of other coils before it finally flows through an-

other resistance to reach the next brush, the loss thus occasioned is small compared to the total loss that would take place in the short-circuited coils were the preventive leads not used.

As a further means of reducing the short-circuit current, the brushes are made with a high resistance which, being in series with the preventive leads, also reduces this current.

Another common means of meeting this difficulty is the use of commutating poles. These are placed at the points of commutation and are so designed that they set up a magnetomotive force which counteracts that of the short-circuited coils. A wide variety of methods are employed in the design and connection of these poles, each with its own particular merit. The design depends principally upon the conditions of load, speed and service under which the motor is to operate. Fig. 8 shows a method used when it is desired either to maintain a constant torque with varying speed or a constant speed with a varying load. In this arrangement, the speed is varied by the regulating transformer; while the voltage applied to the motor varies, that of the commutating-pole winding remains constant.

Another scheme of connections is shown in Fig. 9. In this method, the voltage of the commutating pole varies with that applied to the motor.

An arrangement which has been found to give good results is shown in Fig. 10. In this the commutating-pole winding is placed in series with the armature, but a noninductive resistance is placed in parallel with the winding. The main current passes partly through the commutating-pole winding and partly through the resistance.

Sometimes it is desired to operate series motors on a mixed service, that is, either on a direct- or alternating-current supply. This can be easily done by properly designing the control apparatus. Fig. 11 shows a general diagram of connections used for accomplishing this purpose with railway motors. The solenoid-operated switch closes the alternating-current supply circuit across the contacts *A* and *B* as soon as the current is admitted to the autotransformer. The switch maintains this position as long as current continues to flow through the solenoid. However, as soon as the alternating-current supply is broken, the switch opens the bridge across the contacts *A* and *B* and at the same time closes the direct-current supply circuit across the contacts *D* and *E*, thus changing the motors from alternating- to direct-current control. It will be observed that the motors are connected in pairs, each pair being connected permanently in series. The two pairs can be operated in series by opening the switches *H*, *F*, *K* and *I* and closing switches *C* and *G*. For parallel operation switches *C* and *G* are opened.

For traction work the alternating-current voltage generally employed is 11,000. The motors are usually designed to operate at 250 volts or less, the motors being connected in series groups of two. switches *H*, *F*, *K* and *I* are closed while The line voltage is stepped down to the requisite pressure for operation by means of the autotransformers.

As compared with other types of alternating-current motors the single-phase commutator motor is superior for purposes requiring a heavy starting torque and a ready adaptability of speed to varying conditions of load. The single or polyphase synchronous motors are unsuited for purposes requiring a heavy starting torque as are also the single-phase induction motors. The alternating-current series motor also possesses an advantage over the direct-current series motor in that it can be operated efficiently on a mixed service.

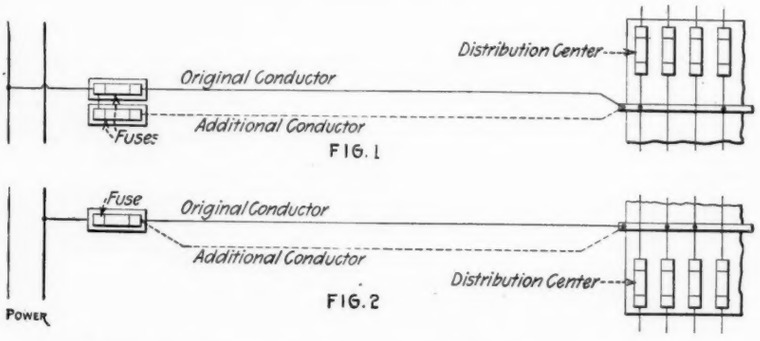
CORRESPONDENCE

Protecting Reinforced Conductors

Where it is necessary to increase the carrying capacity of a circuit by adding a second conductor, it may be done by one of the methods illustrated. If the wires are small and so located as to be easily broken, the reinforcing wire should be protected with its own fuse, as in Fig. 1. Where the wires are large and not likely to break, both the reinforcing and the reinforced wire can be connected in parallel and protected by one fuse, as in Fig. 2. If the second method were used for the conditions in the first case, one of the wires might break and the remaining wire would be protected by a fuse too heavy for it; hence it might become overheated and cause a fire. However, where at all feasible, the second method should be used, because with the first the current is likely to divide unequally between the two conductors, due to differences in contact resistance at the terminals.

CLARE V. SHEAR.

Wilkinsburg, Penn.



MEANS OF PROTECTING REINFORCING CONDUCTORS WITH FUSES

Reversed Polarity

In the case cited by Mr. Mitchell in the July 2 issue, it would appear that the machine was reversed in polarity by putting in the "main switch" after the machine switch was closed, while the dynamo was standing idle. If so, it would surely have caused the polarity to be reversed, owing to the difference due to the voltage of the No. 1 machine and no voltage on No. 2 machine. The usual way of restoring the polarity to its normal direction is to pass an electric current from another machine around the pole pieces, that is, through the field coils, long enough to change the polarity to the right direction. This may be done by taking a separate set of wires from another machine or by using the switch, circuit-breaker and the busbar connection to the machine.

In small plants with small machines it is customary to raise the brushes from the commutator as no current is needed in the armature. But in large stations with large dynamos where there are a hundred or more brushes it is not easy to raise them all; therefore, the cable connection from the brush-holder busbar, attached to the yoke of the machine, is disconnected and may be wrapped with tape and bent back to keep it clear from contact. The current is thrown on the machine by closing the circuit-breaker and then the switch for 3 to 5 sec., after which the circuit-breaker and the switches are pulled out in the order named. The cable is then connected to the brush-holder busbar and the machine brought up to speed and up to voltage. If the voltmeter does not show the voltage to be building up, a portable voltmeter should be applied across the terminals of the switches to be sure the voltmeter on the switchboard is not out of order. If both voltmeters do not show any voltage or sign of building up, then the operation must be repeated and the current left on the machine field coils for a longer time. I have tried this on many machines and they have all come back to the proper polarity.

R. A. CULTRA.

Cambridge, Mass.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

First Diesel Liner to Cross the Atlantic

New York City had its first glimpse of a Diesel-engine driven liner when the new Hamburg-American ship "Christian X" arrived at this port on Sept. 19. A feature which attracted much popular attention, as the vessel came up the bay, was the absence of funnels, the exhaust being through one of the masts.

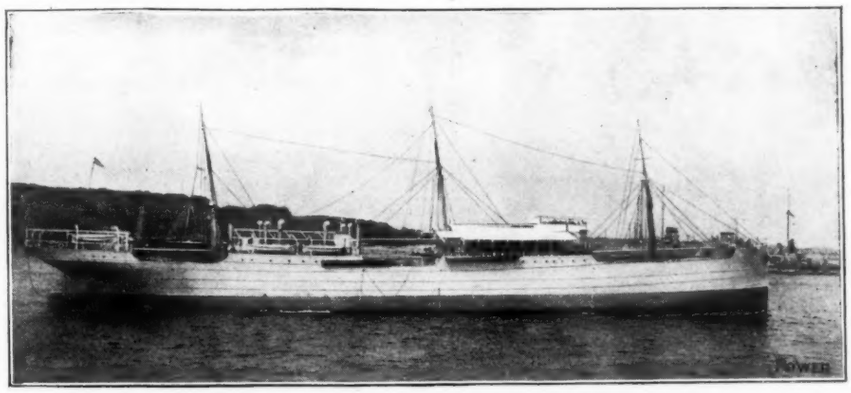


FIG. 1. DIESEL SHIP "CHRISTIAN X"

In many respects the "Christian X" is like the "Selandia" of the same line which was placed in commission last spring (see POWER, Apr. 23, 1912). The latter, however, was designed for service in the Far East while the newer ship is to run regularly between New Orleans and Hamburg. Not only is she the first Diesel liner to enter the Atlantic service, but the first to cross the Atlantic.

On the maiden trip from Hamburg to Havana, thence to New Orleans, the distance of 4627 miles was covered in 17 days at an average speed of 11 miles per hour and at a fuel consumption of 290 tons of oil. This is an average of 16 tons of oil per 24 hr. when developing 2300 hp. or 0.58 lb. of oil per hp.-hr.

During 24 hr. of this trip, however, a special trial run was made on which the average performance was greatly exceeded. The total fuel consumption for this run was 9385 kg., or a little over 10 tons per hour during which the average indicated horsepower was 2383.

The ship was built at the yards of Burmeister & Wain, of Copenhagen, and is 370 ft. long, 53 ft. beam and has a displacement of 9800 tons when loaded. While designed primarily for carrying freight, she also has passenger accommodations for 22 persons.

Power is supplied by two eight-cylinder Diesel engines of the four-stroke-cycle type, the diameter of the cylinders being 20⅞ in. and the stroke 28¾ in. When driving the propellers at 140 r.p.m. each engine develops 1250 hp. A view of the engine room is shown in Fig. 2.

Two 250-hp., four-cylinder, two-stroke-cycle Diesel engines each drive a dynamo and an air compressor. The former supplies electricity for lighting and motors and the latter delivers air at 300 lb. to a tank for starting the engines. A compressor driven direct from each main engine takes air from this tank and compresses it to 900 lb. for fuel injection.

Reversing is effected by first throwing the starting lever into the neutral position; this shuts off the air and fuel supply. Another lever throws into action the reversing mechanism, which is actuated by air at 300 lb., and which shifts the camshaft so as to bring another set of cams under the push-rod rollers. The starting lever is again brought into action and admits air at 300 lb. for over half the stroke, starting the engine in the reverse direction. It might be mentioned that the reversing mechanism cannot be thrown into action until the starting lever has been put in neutral position. It is claimed that the engines can be reversed from full speed ahead to full speed astern in 8 sec. All auxiliary apparatus is in duplicate and all the pumps are electrically driven except the ballast and fuel-oil pumps which are air driven. A donkey boiler supplies a steam-driven four-stage air compressor for supplying air to the starting tanks when the small Diesel engines are not running and the air pressure has fallen.

The oil-storage tanks are in the double bottom of the ship and have a capacity of 1000 tons. From these the oil is pumped to two working tanks, each of 12 tons capacity—more than sufficient for a day's run.

The space taken up by the engine room is 43 ft. of the ship's length and 10 men comprise the engine-room force.

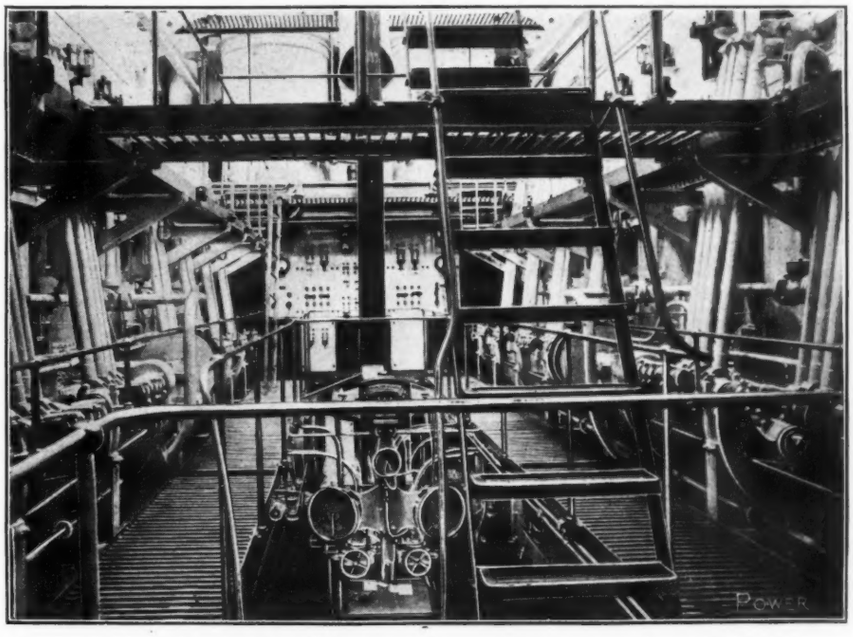


FIG. 2. ENGINE ROOM SHOWING DIESEL ENGINES ON EITHER SIDE

The Bessemer Oil Engine

The Bessemer Gas Engine Co., Grove City, Penn., has added to its product an oil engine, the design of which closely follows that of the gas engine it has been building many years. Fig. 1 shows the general appearance of the new engine. Like the Bessemer gas engine, the new oil engine works on the two-stroke cycle, and the cylinder and piston design and construction are practically the same, as Fig. 2 will indicate to anyone familiar with the gas engine. The front end of the cylinder constitutes a pump chamber into which the air for combustion is drawn by the engine piston and from which it is forced into the power end of the cylinder through the port *A*, Fig. 2. The pump chamber is closed by a head through which the piston rod works in a packing gland.

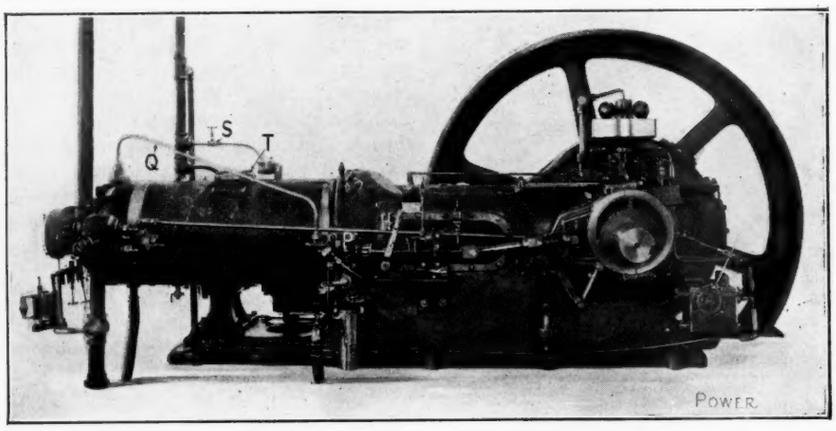


FIG. 1. BESSEMER OIL ENGINE WITH ONE FLYWHEEL REMOVED

The fuel oil is fed to the cylinder by a pump (*P*, Fig. 1), operated by an eccentric on the crankshaft, and delivers the fuel through the small pipe *Q* to the injection nozzle. The latter is shown in section in Fig. 2 at *N*. It consists of a simple plug in which is mounted a check valve of the mushroom form, normally held on its seat by a spring. When the pump delivers a charge of oil, the pressure opens the valve *N* and the oil is discharged on the lip *L* of a vaporizer *V*. This is of the hot-bulb type and the oil vapor is carried into it by the motion of the air in the cylinder, which is being compressed into the vaporizer when the oil is delivered on the lip *L*. Delivery occurs just ahead of the completion of the compression stroke by the main piston.

A special feature of the engine is the admission of water into the cylinder along with the air for combustion. This is accomplished by means of the arrangement shown at the top of the engine cylinder in Fig. 2. Water is supplied from the water-jacket inlet pipe to a little constant-level reservoir *R* whence it passes by a regulating needle valve *S* to the cup *T*. When the piston travels from the position here shown toward the cylinder head, on the compression stroke, the suction in the front end of the cylinder and the annular chamber *C* opens the check valve *U*, and the water in the cup *T* is drawn into the chamber *C*, where it is picked up by the air simultaneously drawn in through the inlet valve *I;* when this charge of air is compressed and finally forced into the power cylinder by the return (forward) travel of the piston, it carries with it the small "dose" of water which was sucked in as described.

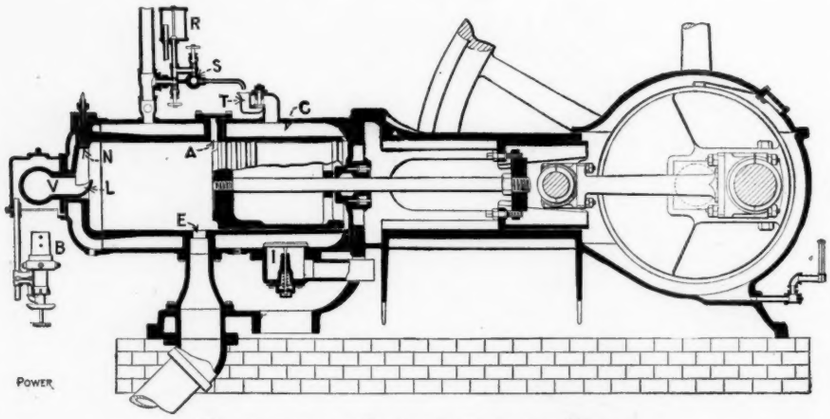


FIG. 2. SECTION THROUGH BESSEMER ENGINE

The object of admitting water with the air is to keep down the explosion pressure, which the water effects by absorbing heat from the burning fuel. The steam thus formed assists in forcing the piston forward, so that not all of the heat absorbed by the water charge is wasted. The question of heat economy, however, is subordinate. The oil engine has intrinsically such high thermal efficiency that it can well afford to sacrifice a little to smooth out the peak of the indicator diagram and relieve the maximum stress at the instant of explosion.

For starting, a small "torch" or bunsen burner *B* is provided for heating the vaporizer bulb, and a compressed-air admission valve is provided at the side of the cylinder head, the engine being turned over by air until it picks up. For stopping the engine, a handle *H*, Fig. 1, is provided, which throws the fuel pump out of operation.

Regulation is effected by a linkage which enables the governor to control the position of a pivoted dog or blade mounted on a slide which is moved to and fro by the pump eccentric. This dog engages with a stepped block fastened on the end of the pump-piston rod, the particular step engaged (and therefore the distance of pump travel) being determined by the position of the dog. The governor is a modified Jahns type.

The engine is supplied with lubricating oil by a force-feed machine operated by a link from the fuel-pump eccentric, as shown in Fig. 1.

Utilization of Waste Heat

Stahl und Eisen for July 11 prints an extract from a paper on the utilization of the waste heat from different prime movers presented by Chief Engineer K. Kutzback, of Nuremberg, at a meeting of a local section of the Verein deutscher Ingenieure. The author says the real reason why the reclamation of waste heat from internal-combustion engines has hitherto played only a small part in comparison with that from steam engines is clearly evident when the quantities of heat available are compared as in Fig. 1.

With the steam engine the available heat is present in the convenient form of steam. Furthermore, a demand such as for heating purposes can be supplied from the receiver. With the internal-combustion engine the waste heat is about equally divided between the cooling water and the exhaust gases.

With the larger gas engines the temperature of the cooling water should hardly exceed 100 deg. F. because of the danger of preignition; hence it is only in the exceptional cases that this portion of the heat is reclaimable. Cooling the jacket water by evaporation is a method frequently applied to small gas engines, but for the larger ones, it is impracticable. With oil engines the conditions are more

favorable as, through absence of the hazard of preignition, the jacket water can be raised to 200 deg. F.

While the use of the moderately warm water from the jacket is easy there are many difficulties in the way of utilizing the heat of the waste gases. These are of large volume, relatively small heat content, and poor heat-imparting capacity (about 200 times poorer than steam). In addition they are fouled by oil, sulphurous acid or soot and their direct application can seldom be considered. On the other hand, they leave the engine at a high temperature, 750 to 1100 deg. F., so that water of 212 deg. F. or with special boilers, steam of 350 deg. can easily be supplied. If the boiler efficiency be taken no higher than 60 per cent., seeing that the risk of corrosion must not be carried to the point where the cooling of the gases would condense their moisture, a recovery of about 2000 B.t.u. per effective horsepower-hour can be had from the exhaust gases of the gas engine and about 1200 B.t.u. from the Diesel engine (see Fig. 2). Although this is only about one-tenth the waste heat recoverable from steam engines, calculation has shown the great advantage of its utilization once there exists a general demand for hot water or for steam, and especially when the installation can be used at a high-service factor so that interest and amortization may not attain a disproportionate relation to the profit.

Fig. 3 shows a form of regenerator made by the Augsburg-Nürnberg Machine Works for the larger gas-engine plants. These are made either horizontal or vertical and are easily freed from scale and sediment on the water side and also permit cleaning on the gas side, though this is seldom necessary. They have the particular advantage that the cleaning can be done without taking down the exhaust piping. The illustration shows the comparatively light outer jacket removed for this purpose, it being necessary to disconnect only one flange. In general the vertical form is used for hot-water supply and the horizontal, by reason of its more favorable evaporating surfaces, for the generation of steam. Both types are built to withstand pressures up to 170 lb. gage and to resist stresses due to explosions in the exhaust line.

The following calculation gives an insight into the economy of such installations: For a 2000-hp. gas engine the regenerator and its accessories will cost from $1600 to $2100. If the annual charges for interest, amortization and maintenance be taken as 15 to 20 per cent. this will represent for one year an outlay for these accounts of from $300 to $400. With such an appliance nearly 2000 B.t.u. can be recovered per effective horsepower-hour; meaning for a 2000-hp. engine an hourly recovery of

$$2000 \times 2000 = 4{,}000{,}000 \text{ B.t.u.}$$

in the form of hot water or of steam. Assuming a cost of $0.0069 for, say, 40,000 B.t.u. generated in the form of hot water or of steam in a coal-fired boiler with coal at $3.50 per ton and a boiler efficiency of 70 per cent., the gain through this waste heat utilization will be represented by an hourly return of

$$\frac{4{,}000{,}000 \times .0069}{40{,}000} = \$0.69$$

With a load factor of 70 per cent. for the engine this means

$$8760 \times 0.70 \times 0.69 = \$4231$$

per annum gained by the utilization of otherwise wasted heat for a yearly outlay of from $300 to $400 so that at least approximately $3800 can be saved and the boiler pay for itself in six months.

In addition it must be remembered that this form of saving operates without attendance. Another favorable point is that any increased heat consumption by the engine through faulty erection or valve-gear or through abnormal ignition is largely recoverable, due to the temperature increment of the exhaust gases and is thus never wholly lost where a regenerator is in use.

If the 2000 B.t.u. per effective horsepower-hour recoverable through suitable construction of the regenerator in the form of highly superheated high-pressure steam be used in a modern steam turbine with an hourly rating of from 12,000 to 14,000 B.t.u. additional power can be developed. This gain of about 15 per cent. in power may be employed for additional scavenging or otherwise used.

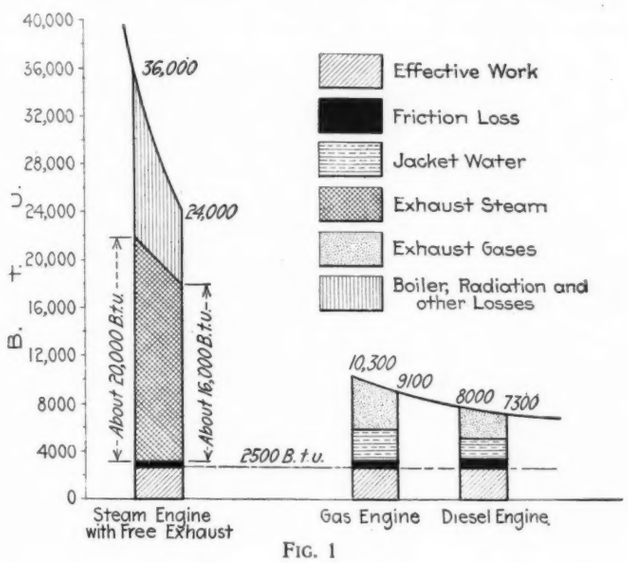


FIG. 1

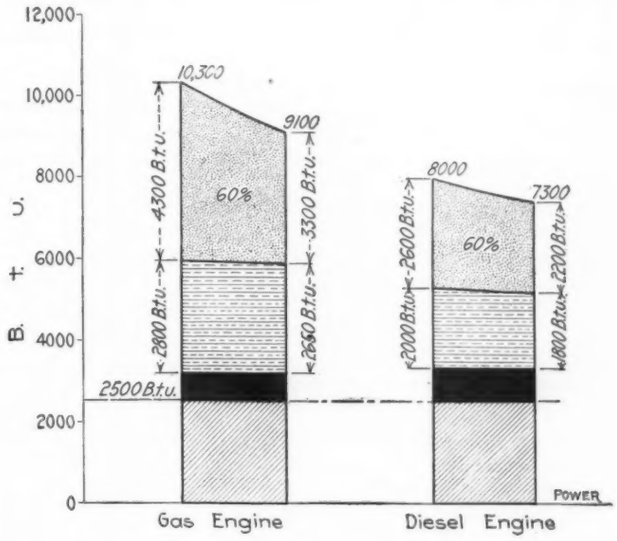


FIG. 2

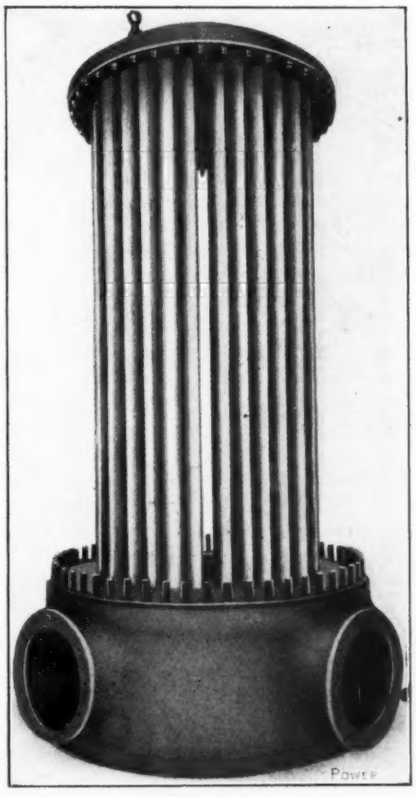


FIG. 3. HEATER WITH CASING REMOVED

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Office Practice in Estimating Heating and Ventilation*

By John D. Small

Before the meeting the author had sent out a number of sets of questions and received several replies. Some of the questions and a summary of the answers are as follows:

What rule do you use for estimating radiation?

Most favored a formula based on the heat units lost through various cooling surfaces and materials and the heat units required to compensate for air change due to leakage and exposure. Coefficient tables for this are found in several handbooks and the losses due to air change represent what the engineer's judgment dictates, except where fixed by law. Carpenter's and Mill's rules are largely used also.

How many air changes per hour do you allow in the following classes of buildings, residences, hotels, hospitals, office buildings, store buildings, theaters and factories (except where exhausters are used)?

This factor seems to be indefinite where the amount of air displaced is not fixed by law or otherwise. In buildings having no mechanical ventilation, the rate of air change would be affected by several causes, a principal one being natural leakage, which varies with the kind of construction, the exposure, the wind velocity and the building height.

Under the head of construction, the kind of window frames used has a great deal to do with the rate of infiltration of air. The sides of the building exposed to prevailing winds will show a marked increase in air displacement over the protected sides. Air currents between high buildings, due to deflection from one to the other, will often affect the surface which otherwise would be protected. Tests made by W. H. Whitten have demonstrated that with wind velocities below six miles per hour infiltration is reduced to a minimum; while with velocities as high as 30 miles per hour a very substantial effect is produced upon the rate of air change of the interior of the exposed portion of the building. Again, the leakage is relatively greater as the building increases in height, due to increased wind pressure. From the foregoing observations it is important to use considerable judgment in arriving at the maximum allowance to compensate for losses due to this element, and in the absence of a fixed rule, the following schedule, in the author's opinion, would be a safe basis for calculating the amount of heat required under maximum conditions of air change in addition to that required to offset losses through the cooling surfaces.

NUMBER OF AIR CHANGES TO BE USED IN HEATING CALCULATIONS

Office buildings—Portions above grade—1 air change per hour.
Basement, general—4 air changes per hour.
Mechanical Plant—10 air changes per hour.

Factory buildings, which have no mechanical or natural ventilation, one change per hour. For factories where large doors from the outside are frequently opened, about four air changes per hour.

Residences—having loose windows, two changes per hour.

Churches—Four changes per hour except small rooms, which should have five or six changes per hour. These data for churches contemplate mechanical ventilation.

The majority of public buildings and many of the factories require ventilation or the fan system of heating. The usual specifications of air supplies per person are as follows:

Hospitals, ordinary—35 to 40 cu.ft. per min. Hospitals, epidemic—80 cu.ft. per min.

Hospitals—Tuberculosis	Air Change min.
Detention room	6
Toilet rooms	6
Bath and duty rooms	8
Kitchen	3
Serving	10
Fumigating	10

Workshops—25 cu.ft. per min.

Prisons—30 cu.ft. per min.

Theaters—20 to 30 cu.ft. per min.

Meeting halls—20 cu.ft. per min.

Schools—30 cu.ft. per min. per child and 40 cu.ft. per min. per adult.

Hotels—Following air changes are usual:

Room	Air Change min.
Engine	6
Kitchen	1½
Restaurant	6
Base toilet	5
Billard	10
Barber shop	8
Dining room	15
Palm room	12
Buffet	8
Cafe	8
Lobby under balcony	8
Main lobby	20
Banquet hall	15
Retiring room	10
Kitchens	8
Toilets	6
All others	15

Libraries Room	Air Change min.
Corridors	15
Basement rooms	15
Reading rooms	12
Inside rooms	8
Corner rooms	7
Toilet rooms	5

Laundries—should have an air change every 4 to 6 min. Radiation on sides of buildings subjected to prevailing and cold winds would be increased 10 per cent. up to the 10th floor and 15 per cent. above.

In your opinion is it more practical to heat and ventilate with hot air only or to ventilate with tempered air and provide direct radiation for heat losses through cooling surfaces?

While opinions differed on this, providing direct radiation for use when fans are shut down seems desirable. It is argued that omitting direct radiation makes heating without ventilating impossible, as the fan must be run to heat. Direct radiation in addition to the fan system, one to offset the cooling effect of walls and glass and the other for ventilation only, makes a flexible system and admits of uniform regulation of temperature for various exposures perhaps better than the fan system only.

The relation of supply and exhaust opening in a given room sometimes results in short-circuiting and defeats thorough ventilation as well as requiring direct radiation to care for parts not warmed on this account. Apparently, therefore, where possible, combining the direct with the blast system would be not only more practical but more satisfactory results could be guaranteed.

Do you consider it good practice to install radiation in factories only sufficient for normal winter temperatures and increase pressure to compensate for deficiency when maximum winter temperatures prevail?

The consensus of opinion is decidedly against this practice, especially where exhaust steam is used for heating, as the engines would be subject to back pressure and general efficiency is reduced. The money saved on first cost of the heating system would be spent in operation later, thus resulting in poor economy in the long run. Therefore, this evidently would not be considered good practice, although owners are often influenced to cut down the first cost in this way, not fully realizing the net result.

Do you advocate using mains as heating surface or covering them throughout?

The conditions and class of buildings govern largely. Under the head conditions, would be considered the cost of covering, the location of mains and the length of run together with the length of risers in connection with the mains. For low buildings and not excessively long runs, the mains are very often left uncovered, and without bad effects. In high buildings and in central heating systems the mains must be covered to reduce the steam pressure and therefore the temperature as little as possible at the terminals. In some cases the steam has condensed to such an extent, due to surrounding temperature, that covering the mains became necessary. Most favor covering the mains, as a rule, for best results in heat distribution.

*Abstract of a paper read before the American Society of Heating and Ventilating Engineers at Detroit.

In large open rooms, such as in stores, factories, etc., would you figure the radiation the same on all sides and then place a larger proportion on the most exposed or windward side? If so, what proportion? Or would you figure it the same on all sides and add radiation on the most exposed sides? If so, how much?

The majority answered the first question affirmatively, the idea being that the heat will equalize, due to wind pressure, and eventually find its way to the opposite side of the building, whereas, if the same proportion were placed all around, the temperature on the windward side would be too low, and on the opposite side too high. To figure the radiation the same all around and then add to that on the most exposed or windward side would require more radiation than otherwise, and would not be so effective and economical as the first method.

If windows are provided with weather strips, would you reduce the amount of radiation? If so, how much?

Ordinarily the sash and frames are assumed to be wood, without weather strips. If concealed weather strips are used the radiation may safely be reduced from 10 to 15 per cent. While if metal sash and frames are used the radiation should be increased.

Open Windows with Mechanical Ventilation*

By Ralph C. Taggart

Ventilation by open windows has been discussed of late and certain misstatements have gained considerable publicity. Its advocates usually maintain that ventilation should be by open windows alone, while the partisans of ventilating systems often claim that no opening of windows should be allowed. They argue that opening windows will upset the balance of the ventilating system and make it ineffective. This closed-window rule has been enforced to such an extent that students in some schools have been suspended or expelled for opening a window.

In the author's opinion no ventilating system should be installed in which the balance of the system is appreciably affected by opening windows. Where the outdoor air is reasonably good and fairly free from dust, etc., a mechanical ventilating system will give as good or better results when used in conjunction with open windows than in any other way, and, further, the engineer who insists upon closed windows is making almost certain the unsatisfactory operation of his apparatus.

To the question what is meant by good ventilation, some will answer pure air. A layman or perhaps a doctor may say "I can tell pure air the minute I enter a room," and this is the way the air is judged by most people. In other words, pure air is what appeals to the senses as pure or refreshing. Good ventilation does not then for most people mean chemically good air. It means air which makes one feel good.

The ventilating engineer, while he has changed some of the old standards by which air is judged, still holds to a chemical test of the air. To the ordinary man, however, air which makes him feel good is air which meets certain physiological requirements. These requirements are not the same for two different individuals, and they are not the same for the same individual at different times of the day or on different days. For many individuals considerable variation may be allowed in most of the qualitative conditions of the air without much discomfort, while sensitive persons can stand only very small variations in the air conditions which surround them without feelings of discomfort.

An able surgeon, two hours after being well satisfied with the air conditions in one of his hospital wards, was very much dissatisfied with them, but a careful examination showed that the conditions were identical. In the meantime he had exercised and eaten a hearty meal, and undoubtedly needed a lower air temperature or perhaps a lower humidity to make him feel as he did at first.

Ventilation involves, therefore, a question of comfort to the occupants of a building which cannot be eliminated. The best that can be hoped for in ventilating a room containing many people is to provide healthful air which will as nearly as possible satisfy the physiological requirements of the average individual.

Imagination has much to do with an individual's comfort or satisfaction. For example, changing the position of a thermometer, has made people who thought they were cold believe they were warm. When the occupants of a building are told that the windows cannot be opened they are very apt to want to open them.

Aside, however, from this consideration, the occupants of a room should have some easy means of changing air conditions within it. No matter how carefully the system is operated; it cannot meet all individual requirements, and not allowing window opening removes the simplest, and often almost the only easy means of controlling certain air conditions.

Where the system is controlled automatically, if the apparatus gets out of order, the room is overheated and discomfort caused if windows cannot be opened. Even if it happens only once in a year; this often engenders an animosity toward the heating apparatus that is astonishing.

Open-window ventilation in rooms occupied by many people is generally suspended in cold weather, because the occupants will not keep the windows open. This means practically no ventilation in the colder weather.

Some claim that air warmed (sometimes styled "canned" air) and then admitted to a room is injurious. If the air is properly washed, very little dust remains, and even if it were all burnt up by the few degrees of warming, the decrease in the oxygen content of the air would be negligible. Air in passing through a steam heater need not be warmed to the excessive temperatures often stated. With steam at 212 deg. F., air cannot be heated in a ventilating apparatus to that temperature, and practically none of it need be heated above 98 deg., or less if desired.

Some engineers maintain that rooms in which windows are opened draw a large part of the air supplied by a fan or blower, keeping other rooms from receiving their share. They may contend that with the ventilating system in operation the various rooms are under considerable pressure. With vent or exhaust flues of any reasonable size, plus the chances for air leakage around the room itself, very rarely will the pressure in any room be sufficientiy above the outdoor pressure to be measurable except by the most delicate instruments. The additional flow of air toward a room with open windows, due to any lessening of pressure within the room, therefore, is usually very small. More likely air will blow into the room from out of doors, reducing the amount taken from the ventilating system and leaving more instead of less for the other rooms.

Assume considerable pressure is carried within the room itself (although this indicates a poorly designed ventilating system) and the wind in a direction to remove air through open windows. An excess of air then will be taken from the ventilating apparatus, but it is not so great as might be imagined, especially if the connections in the branch flues from the main ducts to the individual rooms have some appreciable resistance, as they usually have.

The increase in air supply varies only as the square root of the increased difference of pressure, and if in the original design the branch connections have been slightly choked so as to place the larger part of the duct resistance in these branches, the increase in air discharge into a room with open windows may be made practically negligible.

Some may say that this resistance in the branch connections is very undesirable. It is not if the main ducts are of proper size to minimize the friction within them, and this is desirable, for the main ducts are usually horizontal, and the horizontal ducts should always be large enough to be easily accessible and to keep the total friction resistance within the duct system small. If the friction in the main ducts is small, the friction

*Abstract of paper read before the American Society of Heating and Ventilating Engineers at Detroit.

in the branch connections may also be small, and yet large enough for that in the main ducts to be negligible in comparison.

How small an increase in duct sizes is required to reduce the friction in ducts is often not appreciated. For the same quantity of air delivered the friction varies inversely as the fifth power of the diameter; hence, if a duct or pipe diameter is doubled, the friction is reduced to $\frac{1}{32}$ of its former value. If the duct is increased in diameter only 50 per cent., one of two-thirds its diameter will offer more than 7½ times as much friction, or if the diameter is increased only one-fourth, the friction resistance is reduced in the ratio of more than three to one.

The practice has become common to reduce duct sizes so much that many of the horizontal ducts are practically inaccessible and the friction resistance so great that the use of apparatus frequently is abandoned because of the power required to operate the fan. Main ducts and main branches, therefore, should be made large, while vertical branches should be properly reduced.

Another argument against open windows is that the good air from the ventilating system will escape directly out of doors. Generally speaking, this is not so, and in any event the trouble can usually be rectified.

Some, however, may say that whereas we get pure washed air from the ventilating apparatus, only dusty air comes in through the windows. This is denied by open-window enthusiasts. The truth lies between these two statements. In very dusty localities, air admitted directly from out of doors without washing or cleaning may be objectionable, but usually pretty good air in summer is obtained through open windows, and if it is good enough in summer it should not be rejected because of similar chemical constituents in the colder weather.

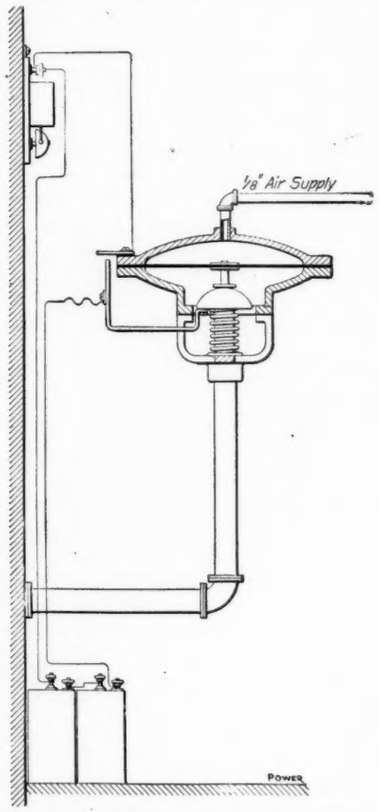
Opening windows to admit air may change the humidity, but if it renders the room more comfortable the author sees no reason why it should not be considered an improvement. There is an element of temperature stratification of the air which seems to be stimulating and invigorating to many people. In other words, air at a dead uniform temperature is not so desirable as air having some differences in temperature. This, insofar as desirable, can often be obtained easily by open windows in conjunction with the ventilating system. It can also be obtained without open windows, but usually not nearly so readily.

Open windows with ventilating systems, in general, therefore, increase the quantity of fresh air supplied; provide means for admitting cool air; give an additional temperature control, and often furnish an easy method of adding to the possible comfort of occupants. Open windows should not, ordinarily, and absolutely cannot, in a well designed ventilating apparatus, interfere with the operation of the system.

CORRESPONDENCE

Air Pressure Alarm

The accompanying sketch shows an electric bell alarm which is used to give notice of a reduction in the air pressure in connection with the operation of thermostatic temperature regulation on radiators and hot-water tanks. This simple alarm has frequently been of great service in giving timely warning of something wrong with the air supply, thereby preventing the hot-water tanks from becoming overheated and the rooms from getting too warm. The alarm is of value in any plant where the air pumps are widely separated from the rest of the machinery and attendants are not always in the immediate vicinity.



ALARM FOR COLD-STORAGE ROOM

The alarm is made from the head, diaphragm, spider, wooden saucer and stem of an ordinary diaphragm valve as used on radiators. This is screwed onto a piece of ⅜-in. pipe and with an elbow, nipple and flange is fastened to the wall of the boiler room. A ⅛-in. pipe from the air tank operates the diaphragm. One contact, a strip of thin brass, is fastened to the top of the head and extends over the edge; the other, a piece of brass rod flattened at one end, is fastened to the wooden saucer or block and is bent upward around the head. These contacts are connected by wires to a battery and bell. While the air pressure is up the contacts are separated, but when reduced, the spring, which acts against a 15-lb. pressure, will force the diaphragm upward, causing contacts to complete the circuit and ring the bell.

FREDERICK G. LEMKE.

New York City.

Saving 50 Tons of Coal

When engaged for my present position I was requested to fire the boiler and to run a 10x20-in. plain slide-valve engine. There was not a steam trap on the place, not even a reducing valve for the heating system, so that when live steam was used it was necessary to turn it on full pressure. The factory was heated by exhaust steam daytimes, and after heating the feed water there was no steam left for one coil. With the exception of the office, live steam could not be used for heating during the day, as the boiler was overloaded. As a consequence the shop was very cold and much time was wasted by the workmen in getting warm.

It was my idea that a reducing valve would help, but the management would not stand the expense. One day I happened to run across a steel drum with a hole in the top of it and decided to make a steam trap. I drilled a hole for a 1¼-in. pipe on one side and a hole on top for a 1½-in. pipe. I got a 1¼-in. valve, filed the thread off the stem and fastened the float to it and the trap was soon complete. All returns from the upper floor came down in one pipe, so I put the trap on the end of it with excellent results. This left out the first floor with nine steam coils, each having a separate drip, but at that conditions were improved.

Next winter I got the reducing valve and a few fittings and put in return pipes and straightened other pipes that needed it. I put the home-made trap on the return of the heating system and it was possible to heat the factory and office on 4 lb. back pressure. The trap and other improvements saved at least 50 tons of coal during the season and on the coldest winter days the temperature on the first floor was maintained at 60 to 65 deg. F. and the remainder of the factory at anywhere from 70 to 80 deg.

THOMAS D. TRIO.

Winsted, Conn.

In Denmark, all the towns of 5000 inhabitants and over are now provided with public electric service. The largest electric stations are to be found at Copenhagen, and at present there are three large plants in operation giving a total of 27,000 hp. Current is supplied for the city mains as well as for the tramway lines.

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POWER

The Brotherhood of Power Workers

An organization, the aim of which is to educate, protect and uplift all having to do with power-plant work is the Brotherhood of Power Workers, referred to elsewhere in this issue. The coal passer is as eligible to membership as the chief engineer and the educational program provides that his questions shall receive the same consideration as those of his chief.

The organization aims to increase the wages of power-plant workers, not by fostering antagonism between employer and employee, but by educating the worker to a point of efficiency where the employer will be glad to pay for the superior service. It does not participate in labor disputes unless appealed to by a member and then offers the services of an arbitrating committee. However, its members are forbidden to fill positions vacated by organized strikers.

Those desiring to obtain city or state licenses or take civil service or other examinations are coached by an examining board. There is a sick and accident, as well as a death benefit to which all members are entitled. It is proposed to eventually add an insurance department to facilitate payment of the above benefits.

This organization should prosper, grow and realize its aims inasmuch as it is broad in its scope and sound in principle, and it will so long as it allows nothing to divert it from its present constructive policy. We hope the fireman member will receive the consideration it is proposed to show him. Firemen are handicapped in getting the knowledge necessary to make them engineers. In most plants they are not allowed to leave the boiler room while on duty. This is as it should be, but the opportunities for becoming familiar with equipment in other parts of the plant are lacking. The work is hard and he is in no humor to read or study when the day is done. The discussions that he would hear and participate in at the meetings of a good organization would, therefore, be of inestimable value not to the fireman alone, but as much so to the engineer.

We wish success to the Brotherhood of Power Workers. It is founded on right ideals and should be an important factor in improving the conditions and elevating the standards in the field which it serves.

To Foreword Contestants

So numerous have been the replies to the offer for forewords and cartoons printed on the first page of the Aug. 13 issue, that we must bespeak the patience of the contributors until the editors can pass upon them. As far as possible, those obviously unavailable are returned at once. Others surely acceptable or likely to be with a little modification, or suggesting ideas that can be made use of, are put aside for further consideration. The receipt of all matter is immediately acknowledged, but for the above reasons final acceptance may be a little deferred. Contributions will be paid for as fast as accepted, although it may be many weeks subsequently before they appear, since only one can be used each week.

The above will show the necessity of our asking indulgence on the part of contributors that they may not be too hasty in concluding they are being neglected.

A word of caution to those who have yet to submit matter. Many contributions have involved POWER itself in the treatment of an idea. Much as we appreciate the compliment, we do not want to hold up the paper as a panacea for all operating ills. It would seem indelicate and moreover advertisements of POWER are not what we are after. One very carefully drawn cartoon we regretted having to return for this reason. Had we anticipated the possibility of contestants falling into this error, we would have warned against it in our original offer. We trust that all further contributions will be strictly impersonal so far as POWER is concerned.

As stated in the offer, we particularly desire cartoons. The ideal cartoon tells its own story with no explanatory text

beyond a caption and is directly applicable to the operating field. It may point a moral, contrast existing power-plant conditions, etc. Some submitted have been more appropriate for educational textbooks or advertisements and one was strictly allegorical. Such are not wanted, nor those that harp continually on the dirty engine room or the slovenly or bibulous engineer. These conditions and habits are too obviously wrong to need further emphasis.

The range of subjects is wide and it is the quest for new ones that occasioned our offer. Although many contributions have been received already, they have scratched only the surface of the possible field and we trust our readers will continue to put their wits to work and send in more. Good ones will always be available, but efforts must be confined to the power field and the paper left out of sketches or discussions.

Technical Training

About ninety per cent. of our children it is stated finish the grade or grammar schools, five per cent. the high schools and two per cent. the colleges and universities, including the professional schools.

As the industrial tendency is to use machinery more and more, good engineers are needed to plan and design, and skilled men to produce the parts, and assemble and erect them. Capable salesmen also are needed to dispose of the output. The amount of skill and training required varies greatly with the position. There are plenty of men for the lower places, for machine tending, but they become fewer as the demands upon them become greater and more highly technical.

An attempt is being made to meet these industrial needs with engineering, technical, vocational and trade, correspondence, Y. M. C. A. and public evening schools, as well as schools run by the manufacturers in connection with their works. But more are needed and more must come. The wage earner must specialize along definite lines. But what can a man do who has left off his education with, say, the grade school and has started in the industrial field? He has begun to see that more education is needed, more knowledge of the principles and reasons underlying his work or the trade in which he is engaged.

Naturally the question must be answered and a few suggestions may guide him in his choice of methods. He must consider that he has available only a certain amount of energy each day. If he is busy at work all day, he may be sleepy, fagged out and unable to take advantage of night schools or to study evenings by himself in correspondence lessons. Many have, however, been helped by these schools, especially when day duties have allowed a chance to study lessons at the same time. Studying alone and getting out hard problems unaided is fine training, but gives no means of comparing one's self with others; it is like a one-man race, no pace- makers or competitors by which to measure one's ability.

A course of training, taking a subject at a time and studied but a little each day, extends the time needed to complete the desired subjects over many years. Of those persons who start out with strong intentions, very many fail to continue to the end, perhaps because studying is hard for them, or their daily duties change, or their determination gradually diminishes.

As to the length of time needed, it must be recognized that nature has certain laws in the realm of mind as in that of matter, and that the one especially applying here is that the older one grows the longer it takes him to learn new things; and so while a man is slowly completing night and correspondence-school courses, he is growing older and the last work will come still more slowly. Also the advantage of having the training is less, when it has finally been secured.

It would then be better where possible to make a business of getting the needed education and training while young. This means in part attending some school where the student can devote himself to study, can receive needed guidance and help day by day, can measure himself by his classmates, can learn from their questions, can take advantage of the best time of his life for learning. And when he has mastered the principles and has been started in their applications, he can continue to apply them to advantage to himself and his employer in the everyday work of the plant.

If it is a question of money, it is suggested that he write to the different schools that offer studies and training along his line, to trade schools, to institutes giving industrial training, to engineering schools and to state universities. Let him learn first the cost per year and then figure out what he can make per year in the summers and weeks when the school work is not in progress. There are numerous young men already putting themselves through these schools, paying their way by various means, and many of them standing well up in their classes.

If he does rely upon his own exertions to pay his way through, he must be prepared to take extra time for the studies, even an extra year, and study fewer subjects each year to allow the time for the paid work. This is necessary so that he can study at more nearly full pressure and to better advantage. Otherwise he may "sacrifice his education for the means of getting it."

Another plan is to borrow the money. A young man hesitates to run into debt. But one would borrow to go into a profitable business and what better business could a young man engage in than in transmuting borrowed money into the capital of an education. This borrowing must be done by giving a note. With no property for security, let him procure a life-insurance policy of perhaps a thousand or two thousand dollars, and borrow on it from some kind friend or philanthropic party, a sum to cover his estimated expenses plus the insurance premiums and interest for the period of his studying. The life insurance is made payable to the lender of the money and secures him in case of the death of the borrower. It is assumed that the young man is honest and will pay back the money if he lives. The note may be renewed from time to time, after he is again earning money, but for reduced amounts.

It is easy reckoning to see how long it would take him at his present wage to make complete payment; after his course of study he should be able to increase his wage gradually and so clean up the debt sooner. It is quite a surprise to find how many are ready to extend a favor to an earnest, honest, capable fellow who is seriously striving to improve himself.

To the young man with no family ties this suggestion is worth thinking over. What is worth while comes only by effort. Keep striving, but if you expect the chips to fly, use the edge of the axe and see that it is sharp.

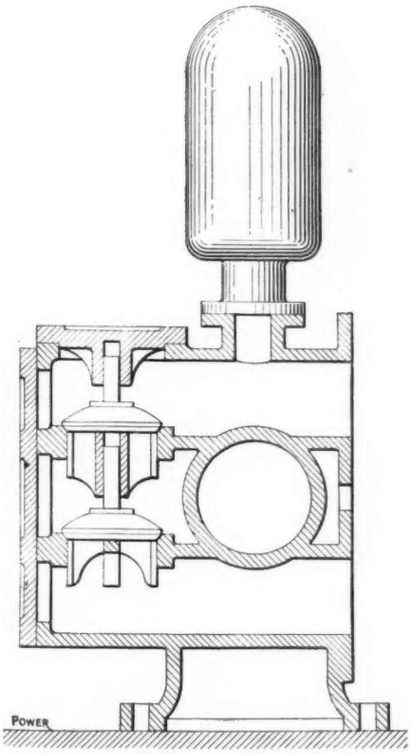
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Effect of Valve Position on Pump Efficiency

The effect of the position of the valves in an ordinary plunger pump upon its efficiency is interesting. Upon several occasions I have observed plunger pumps with the suction valve immediately under the discharge valve, as shown in the illustration. In testing them I was astonished to find that the actual quantity of water delivered was in excess of the theoretical capacity of the pump.

The explanation is very simple as I understand it. A certain momentum is given to the water in the suction pipe during the suction stroke, and when the plunger starts to return, this momentum holds the suction valve open for an appreciable length of time, allowing water to pass directly from the suction through the delivery valve with the re-directed water from the plunger.



SHOWING POSITION OF VALVES IN PUMP

This, of course, would not occur to any extent if there were much head on either valve, but I thought it an interesting point to bear in mind in pump design.

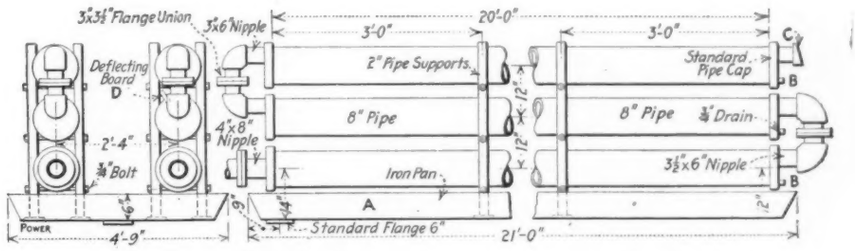
G. H. HUMM.

Loughboro, England.

Condenser Made of Eight Inch Pipe

The illustration gives the details of a steam condenser made of old 8-in. pipe and a few fittings. The iron pan *A* was made at the factory, but a wooden pan could be made more cheaply and be just as serviceable.

The pipes for distributing the cooling water are not shown. Perforated or slotted pipe can be used very satisfactorily. A wooden trough with saw teeth cut along the two upper edges, is an effective and easily constructed means of distributing the water. The ¾-in. drain pipes *B* at the lower end are to be connected with suitable pipe and fittings to take away the condensate.



HOME-MADE CONDENSER CONSTRUCTED OF PIPE AND FITTINGS

The pressure-relief valves *C* are not altogether necessary, their use depending upon local conditions. The deflecting boards *D* (one board only is shown) assist materially in distributing the cooling water over the lower pipes, and also prevent water from splashing outside of the pans. These boards (of 3-in. flooring) should be on both sides of the lower pipes and extend the length of the condenser. The edge next to the pipe should be cut to let the water pass under it.

The writer does not know how much steam, in pounds, the condenser will handle, but the following sizes of pumps, etc., are now exhausting into it:

Four 8x36-in. deep-well pumps, operating at 20 r.p.m.; one 7 and 4 by 10-in. boiler-feed pump; two 9-in. air pumps; one 8 and 6 by 4-in. single, double-acting, brine pump, operating at 40 r.p.m. and one high-speed 9x12-in. slide-valve engine. So long as the condenser is reasonably free from scale, and a thin skim of water is kept running over the 8-in. pipes, no steam escapes from the relief valves, one being shown.

A number of its features make this condenser attractive to the owner, as well as the engineer. The first cost is small, when compared with other condensers of equal efficiency and durability. The one shown cost $90, including new pan, caps, ells, nipples, pressure-relief valves, and labor to assemble the parts. The engineer at the plant can put together and erect the condenser without any trouble. The round surface of the pipe facilitates removing the scale. If the pipes are well painted before being put into operation, a sound blow from a light hammer will loosen the scale. The round surface also aids in better distributing the cooling water, getting at the steam from all sides, as it were.

When the condenser is badly coated with scale, there will be a loss out of the relief valve not only of steam, but of considerable distilled water. This serves to remind the engineer that it is time to clean the condenser.

It is readily seen that repairs can be made to this style of condenser very cheaply and quickly. Should a hole come in one of the 8-in. pipes, tap it out and plug it. The nipples can be renewed easily and the flange unions allow renewing the 8-in. pipe. I have had one of these condensers in operation for six months, using cooling water at about 75 deg. F., having about 30 grains per gallon of scale-forming substances, and have found it very satisfactory.

GAY A. ROBERTSON.

Louisville, Ky.

Steam Gage Problem

Upon taking charge of a plant, I noticed that the steam gage did not agree with the safety valve. It behaved as follows upon firing the boiler:

On Monday morning I could not raise over 20 lb. pressure on the gage, and the safety valve, which was set to operate at 100 lb., would blow off. The gage registered an increasing pressure until

at the latter part of the week it would agree with the safety valve.

I concluded that the gage was out of order, and not having a reliable one, I asked the superintendent to have the gage tested. His answer was that there was no money to pay for it. I called his attention to a circular issued a short time before which stated that the engineer in charge and the superintendent were held responsible for the safety of steam boilers and other machinery. Then I was allowed to have the steam gage corrected, which cost 75 cents.

The gage was corrected with a standard gage and the variation was found to be about 7 or 8 lb. I replaced the gage and after a few weeks it began its same old trick, but this time I thought the trouble was in the safety valve. I overhauled and cleaned it thoroughly and figured the weight that should be placed on the lever to allow it to blow off at 100 lb., and the marks on the lever corresponded with the weight.

To get a new gage was almost financially impossible. The heating season was almost over, and as there was a high-pressure gage on the heating boiler, I placed it in connection with the other. On starting up the gage from the steam-heating boiler registered 100 lb. and the safety valve blew off while the other gage registered about 20 lb. as usual. At the first opportunity I took the steam gage down, examined, cleaned and replaced it, but with no better results.

Can some interested reader explain what caused this trouble? I believe the spring has lost its elasticity, but why did it register the correct pressure toward the latter part of the week?

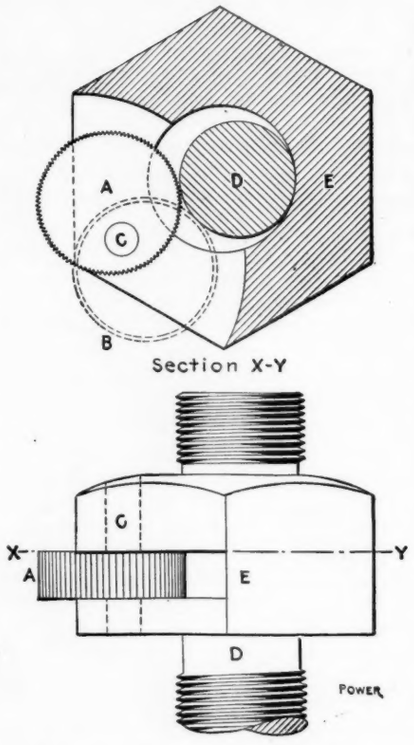
ANGELO BELMONTE.

Stewart, Nev.

A Simple Stud Puller

The illustration shows how a simple stud puller may be made. *E* is a hexagonal piece of machine steel of suitable size, depending on the job. An old nut will not do very well as there is not sufficient metal between the thread and the outside surface. A plain cylindrical hole is made in *E*. A slot is milled in one side, as shown, to accommodate the knurled eccentric *A* and a hole is drilled for the pin *C*. The eccentric *A* should be made of tool steel, hardened and the temper drawn to purple. The pin *C* should also be made of tool steel and the temper drawn to the same color. The body *E* may be left soft but is better case-hardened.

The action is as follows: For screwing a stud in place, the stud *D* is screwed in as far as it will go by hand. The puller is then placed over the stud and the knurled eccentric pressed against the stud *D* in the position shown at *A* in the cut and the wrench applied. Obviously, the greater



SHOWING CONSTRUCTION OF STUD PULLER

the resistance of the stud *D* the greater the grip of the knurled eccentric *A*. To remove a stud the eccentric is swung to the position *B*.

L. A. SUVERKROP.

New York City.

A Thoughtless Fireman

On Sundays and holidays in winter one of our boilers is always under steam pressure as required by insurance companies. Out of twelve boilers, three and sometimes four are washed every Sunday. An 8 and 8 by 6-in. feed pump furnishes washing water at a pressure which quite well taxes the strength of our big fireman who handles the hose.

The regular feed pump moves very slowly and feeds the boiler in service, since the heating system remains in operation perpetually during cold weather. The feed pipe, therefore, always contains hot feed water. An independent line is used to convey the wash water to the boiler room and at two remote points are hose attachments. The wash water comes directly from under ice on the pond, so the temperature can be conjected. Now that I have given a fair idea of the conditions necessary to the understanding of what follows, here is the point of my story:

This fireman had been on the job five years, and every winter the washing of boilers was torture to him. He would remove the two lower front handhole plates, the upper front, and so on with the rear plates and then stick the hose in the top hole, start the pump, and wash the crown-sheet in the usual manner, using a 4-ft. pipe screwed to the hose end. The other end had an elbow and nipple to deflect the flow sideways between the tube ends. The scale and other impurities followed the water, falling down into the water-legs. Then, after all crown-sheets had been thus treated, he would stop the pump, remove the 4-ft. pipe and use one a foot long instead, for lower regions. After shoving it into one of the apertures he would start the pump again. Sometimes the force would wrench out the rubber pipe and irrigate the floor, and the big fellow would rush in all excited from the pump room in an endeavor to impede the disturbances. In chasing the wagging hose which twisted and swung with all the nimbleness of a snake, from one end of the room to the other, he would receive a none too gentle whack that would cut and perhaps lay him low for a moment.

I entered one cold Sunday morning, and found him crouched low, sucking his fingers, and on the verge of tears. He said his fingers were frozen stiff from washing the first boiler. I asked him to show me how it had happened. He stuck his stout arm into one of the lower holes and inserted the spout of the hose with it. He pulled out whatever scale he could with his hand while the water washed away the remaining mud.

I felt the water and must admit that it was pretty icy; it was no wonder his hands were stiff. "Keep on," I said, "and I'll fix things so you'll be more comfortable." As I spoke I reached out and cracked the feed valve; we heard the hot water oozing. I opened it a trifle wider and gradually he felt the water grow warmer. It was a simple expedient, but in five years he had never thought of it.

LUKE MARIER.

Fall River, Mass.

Blowing Down Return Tubular Boilers

Some engineers declare that the proper time to blow down a boiler is before starting the day's work or at least some time after closing down and after the sediment has a chance to settle, but I prefer to blow down a boiler while the water is in circulation, for the following reasons:

By giving the sediment a chance to settle, it will collect on the upper part of the tubes and the lower part of the boiler shell. I consider that very little that lodges near the entrance of the blowoff pipe will ever move from its position. But if the boiler is blown down while the water is in circulation a large portion of the impurities held in suspension will immediately head for the entrance of the blowoff pipe, and more of it will

be carried away in the same amount of water than if the sediment is allowed to settle.

A. J. FERGUSON.

Vernon, B. C.

Zinc Slabs as Corrosion Preventives

Our insurance company has recommended slabs of zinc suspended in our steam boiler to prevent pitting of the tubes and sheets.

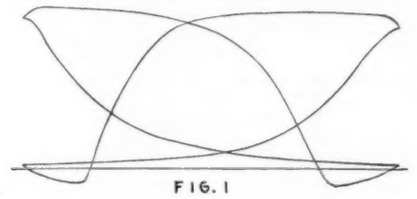
The boiler is of the Scotch marine type, dry back, return-tubular, 50-hp. and used for low-pressure heating. I would be pleased to have suggestions from readers as to the best method of doing this, and of the results obtained.

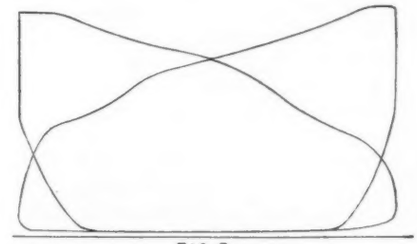
HOWARD L. STAFFORD.

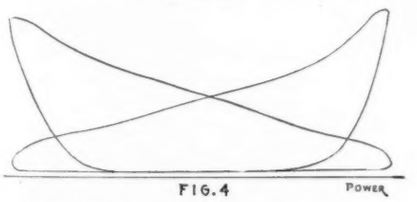
New York City.

Poor Engine Economy Due to Faulty Valve

Our large engine would not pull the load, and the owners thought it too small.







DIAGRAMS SHOWING IMPROVEMENT OF VALVE ALTERATIONS

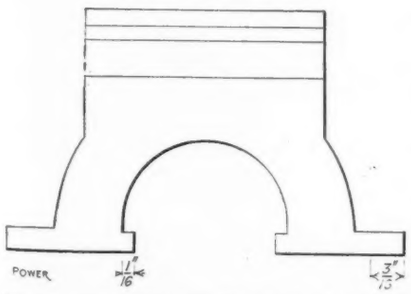


FIG. 2. SLIDE VALVE SHOWING AMOUNT CUT FROM STEAM AND EXHAUST EDGES

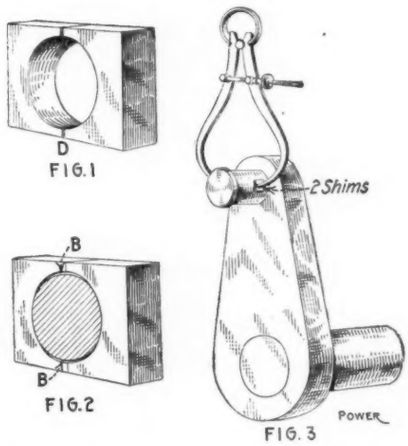
I blamed the engine and on indicating it obtained the diagram, Fig. 1. This card set some of us guessing, so we removed the valve, Fig. 2, and took it to a near-by machine shop and had $\frac{1}{16}$ in. planed off of the exhaust edges and $\frac{3}{16}$ in. from the steam edges. Then we replaced the valve and advanced the eccentric until the lead was what we thought about right—something less than $\frac{1}{16}$ in. We then took the diagrams, Figs. 3 and 4; they are not bad for a throttling engine. The engine could carry the load, and much more than was needed. I think there are more of these engines running in such condition than many suppose.

C. R. MCGAHEY.

Baltimore, Md.

Fitting Crankpin Brasses

A large cross-compound condensing Corliss engine of which I once took charge, I had been warned would give trouble because the high-pressure crankpin was always running hot. My predecessor explained that the trouble started about a month before, when the master mechanic fitted the brasses. I asked the master mechanic how he did the work and found, as I have before, that in fitting them they were put on the pin separately and fitted for high places. After much trouble I refused to keep the job unless the brasses were taken out and fitted according to my method, as life became unbearable under such conditions.



CORRECT AND INCORRECT PIN BORE. CALIPERING PIN FOR CORRECT BORE

I first took off the strap, jib and key and put a block next to the inner box to take the place of the end of the rod, and put two $\frac{1}{16}$-in. shims between the boxes at *D*, Fig. 1, and then keyed up solid. Then I took them to the lathe keyed up solid and took two pieces of shims of the same thickness as before at *D*, Fig. 1, and placed them on the side of the pin and calipered the diameter, as shown at Fig. 3. The boxes were then bored to this size. Then the shims were taken out and fitting commenced. Boring the pin hole larger than the pin is done so that when the boxes are fitted there will be a space at *BB*, Fig. 2, which collects oil and distributes it evenly over the pin and allows of further adjustment.

Next I took some Prussian blue paint and put a very thin film over the pin, and then put the boxes on the pin and keyed up easy so there would be no play, using the block in the strap instead of the connecting-rod. The boxes and strap as connected were turned around on the pin, thus marking the high places, then taken off and these spots scraped. This was done several times until a perfect fit was made. The boxes were put on and the engine run slowly for about an hour with no signs of heating, and they are runing today with no tendency to heat. Where loads are light, it may be that brasses, put on the pin and fitted separately, have worked all right, but when the brasses must be keyed up solid on the pin a different condition exists and calls for a more refined fitting of them.

A. C. WALDRON.

Revere, Mass.

"Knocking"

Some men have a disagreeable way of "knocking," and creating discord wherever they work, because they think such tactics will gain favor for them from the boss. Some bosses also "knock" to the "old man" on slight provocation.

When a workman is unfortunately responsible for a trivial offense it is better to attribute it to "accident" and not create discord. Nine times out of ten, such procedure, together with a private, but friendly reprimand, will bring about better results than running to the old man; but if the case demands reporting at all, why not give such information to him in the presence of the accused?

A case recently came to my observation where an engineer "knocked" a fellow workman in this manner. While moving some lumber up over a small steam pipe a board was dropped upon the pipe, causing a 2-in. gate valve to rupture. The engineer reported him in such a manner that the firm kept $4.75 of his wages to pay for the damaged valve.

A few days later this engineer's carelessness caused the ruin of a 50-ft. stack which he was lowering. He was quick in reporting the trouble as being due to his negro helpers, and he "got away with it."

I do not advocate this policy of laying many things to unavoidable accidents so that someone may break or tear up anything that suits his fancy, but to give everyone a square deal.

I do not believe that a man should be held responsible for accidents to the extent of being made to pay the damage.

LLOYD V. BEETS.

Nashville, Tenn.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Stopping Leaky Rubber Diaphragms

In the July 30 issue, M. S. Weil tells of stopping the leaks in rubber diaphragms with molasses. This treatment may be all right for clear rubber or for diaphragms where the molasses only gets on the surface, but I tried it once for single-tube bicycle tires, the construction of which is much the same as many diaphragms, and found that it separated the plies of the tire and so weakened it that it went to pieces in a couple of days.

A very effective treatment and one that does for any kind of diaphragm is an application of ordinary rubber varnish or roofing cement that comes with some kinds of paper roofing. Leather, rubber or cloth thoroughly impregnated with it will remain air or water-tight for a considerable length of time and it cannot hurt or injure their construction.

A. A. BLANCHARD.

Lakeland, Fla.

Making a Water-cooled Brake

A. T. Kasley's experience with soap and water to prevent a prony brake from sticking is very similar to mine. Graphite will answer the same purpose.

An inexpensive water-cooled prony brake pulley for temporary use may be easily made for testing small engines or motors without buying a flanged pulley. For testing a 15-hp. motor with a normal speed of 1720 r.p.m., an old 10x12-in. iron pulley that fitted the motor shaft was used. Flanges were made for it by cutting rings from a ¾-in. pine board to make a snug fit on the inside of the pulley rim. The rings were about 1½ in. thick with a small flange to fit against the outer edge of the pulley. After forcing these rings into place on each side of the pulley and soaking them with water, a flanged pulley was produced as good for a temporary job as those with the flanges cast in place. A cross-section of the pulley with the flanges *A* in place is shown at the left of the illustration.

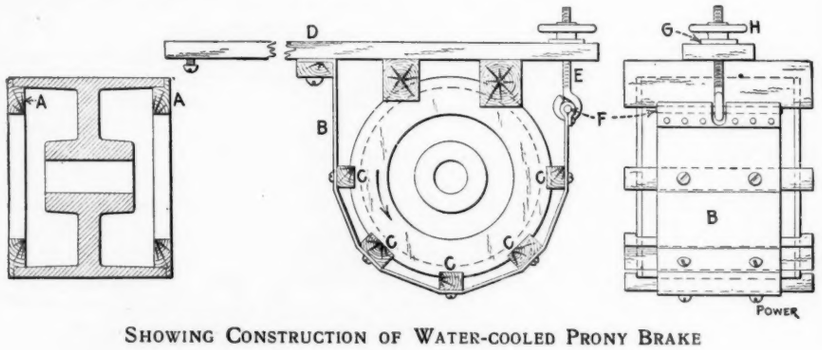
The brake band *B* was made from an old piece of rubber belting with hardwood strips screwed on the inside to act as as rubbing pieces. One end of this was firmly fastened to one end of the lever arm *D*, the other end was doubled back and riveted, making a small loop. At the middle of the belt a hole was cut into this loop and a long threaded eye-bolt *E* placed with the eye in this hole so that a bolt or short rod *F* could be run through the loop and the eye. The threaded end of the eye-bolt was then run through a hole in the lever arm, and a washer *G* and nut or a handwheel *H* with a threaded hole was screwed on the bolt. This gave a simple means of adjusting the tension of the brake band.

By a little preliminary calculation the length of the lever arm may be found which will materially reduce the amount of the final calculations necessary to determine the horsepower from data taken during the test. In the old familiar formula of

$$hp. = \frac{2\pi Pln}{33{,}000} \text{ or } \frac{Pln}{5252}$$

where

$\pi = 3.1416$;



SHOWING CONSTRUCTION OF WATER-COOLED PRONY BRAKE

P = Weight;

l = Length of the lever arm;

n = R.p.m.

If l is made equal to 5.252 ft. we have for the hp. $\frac{Pn}{1000}$. If this is too long or too short an arm for the size of the brake, any even multiple of this length may be used and the constant changed as follows:

10.504 ft.	2 Pn/1000
5.252 ft.	Pn/1000
2.626 ft.	Pn/2000
1.750 ft.	Pn/3000
1.313 ft.	Pn/4000

The brake operated very satisfactory up to 22 hp., which was the maximum capacity of the motor. To supply the water which was evaporated from the inside of the pulley, a short piece of ¼-in. pipe with a cock on one end was fastened into the side of an old gallon tin can, the can was filled with water and placed so that the cock extended to the inside of the outer flange of the pulley, then the cock was adjusted to supply water at just the rate of evaporation.

B. A. SNOW.

Canon City, Colo.

Overspeeding of Turbines

I have read several accounts of turbines overspeeding and was especially interested in Mr. Martin's letter in the June 11 issue and Mr. Hawley's comment on it in the Aug. 13 issue.

A little more than a year ago I was promoted from watch engineer to chief of a 3000-hp. turbine plant having two turbines of 1500 hp. each, where we had considerable trouble with turbines overspeeding. My first endeavor was to overcome this trouble and I was completely successful.

Observations prompted me to make the following changes: We removed the primary valve and thoroughly cleaned the pistons and cylinders. I made new bushings for the valve spindles. allowing 0.007-in. clearance and ground in the needle valves and closed them tight, depending on leakage through the bushings to operate the valves. I also fitted a plug in the hollow end of the spindles so that no steam could pass up through them. Then I drilled a $\frac{3}{16}$-in. hole through the cap under the lower end of the spindle to allow any accumulation of water to pass into the turbine. In assembling the valve I gave the steam piston $\frac{5}{16}$-in. clearance and the dashpot piston ⅛-in. clearance.

As the admission of steam for operating the valves is greatly reduced, the tension on the springs is necessarily reduced in proportion. This is best determined by running the machine and increasing

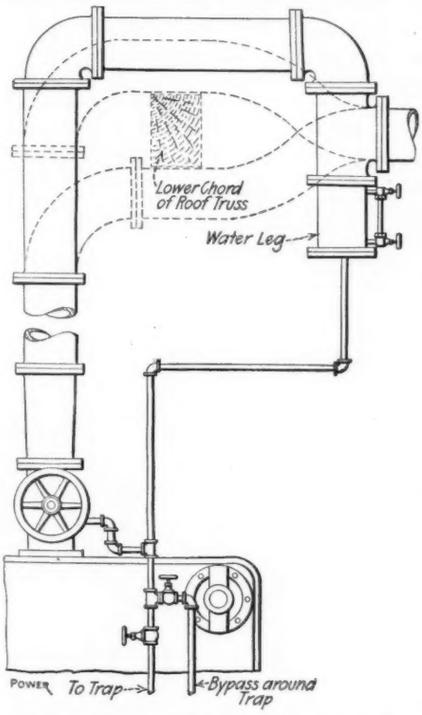
the tension until the valve seats properly. I have also entirely discontinued using oil on these valves, and during the past year our turbines, carrying a load that fluctuates from zero to overload with 175 lb. steam and 29-in. vacuum, have given no indication of overspeeding.

DAVID CRAFT.

Flushing, L. I., N. Y.

Damaged Steam Pipe Due to Faulty Design

In the issue of July 30, under this heading, the original design, and the suggested improvement are alike bad. If the designer of the original arrangement called himself an expert in the design of high-pressure steam-pipe lines, he certainly misunderstood himself. Mr. Parker's suggested improvement would probably be less effective than he believes, as when the water began to trickle back to the boilers (and that suggests that it would be interesting to see the rest of



PIPE LINE IMPROVED TO INSURE DRY STEAM TO ENGINE

that pipe line) there would probably be serious damage done to the pipe.

One of those trickling drip jobs was responsible for an accident in a plant where I worked, making the place resemble what the infernal regions are supposed to look like, with scalding steam, flying bricks, pipe, fittings and pieces of engine all about.

My advice to every man in any way responsible for high-pressure steam work is: Do not take any chances, never under any circumstances design a pipe line with the water flowing against the steam; keep them both going the same way, and get it away from the steam as soon as possible. If a vertical line occurs in a design, always provide a large drip leg the full size of the pipe, the contents of which should be taken care of with a trap. If the trap fails to operate throw the line open to blow the steam through.

The full lines in the illustration show how I would reconstruct the pipe line in question. The dotted lines show the original piping and Mr. Parker's suggested improvement.

J. P. LISK.

Brooklyn, N. Y.

Mr. Parker severely criticizes the design of a 10-in. steam pipe to an engine. He proposes a change in piping to prevent the accumulation of water. Now, if I get the correct idea of conditions, I agree with the owners that the pipe is all right as it is and that they should look elsewhere for the trouble.

In discussing the suggested change we will admit that with the throttle valve closed and no flow of steam in either direction the condensation would trickle back to the boilers after his proposed change, but what would it do while the engine is running? It seems to me that we would have an ideal "pocket," the velocity keeping the water from trickling back and the upset in the pipe preventing it from passing on with the steam or out through the trap, as it should. This trapped volume of water will steadily increase until a "slug" will be taken over into the cylinder and a blown out cylinder head or a wrecked engine may result.

This "trickling back" proposition is not always satisfactory in practice. I would suggest installing a steam separator of ample capacity directly over the throttle valve and a trap that can be relied upon to drain this separator; to be safe two traps might be connected in multiple so that if one failed the other could do the work.

I do not see how, with the throttle closed and the engine shut down and no flow of steam in the pipe, there could be water-hammer to break the elbow referred to after the vertical pipe has filled with water. Some explanation is due here.

Incidentally, the blowing of steam into the engine room after the elbow had broken and having to go to the top of the boilers to close the valves are in themselves a very strong recommendation for using automatic stop valves. I am a great believer in automatic stop and check valves and think they should be used on all boilers, especially where two or more are connected in a battery, as a safeguard against just such occurrences as this one.

M. C. ST. JOHN.

Houston, Tex.

J. W. Parker shows a queer design of piping, but so far as his trouble is concerned I do not believe the piping to be the cause. The drip arrangement should be looked after and should keep the pipe clear of water. I know of no method of piping to a dead end that is not subject to water-hammer.

The change proposed by Mr. Parker is likely to give the engine a dose of water while running if the pipe is of ample size, unless it has a steep pitch toward the boilers, and that would look worse than the present arrangement. I should have a long sweep bend at the engine, and no trap on the steam-line drip to bother me, but instead would put a valve on the drip line at the throttle. When the engine is shut down this valve would be left "cracked" to the atmosphere. With a little experimenting there need be very little waste and the pipe can be easily kept free of water.

LEIGHTON JOHNSON.

Exeter, N. H.

Small Turbine Accidents

Paul Hoffman's article on steam turbines is excellent, but as I came to where he stated that "in small turbines a man looked at them once or twice a watch, etc., and they keep running for years without interruption or repairs and practically no maintenance cost," I wondered if he had stood beside a small impulse geared turbine and listened to it running apparently as smooth as a watch and suddenly to hear a rumble, an explosion of oil and a screech that made one's hair stand on end. This happened to me and upon opening the gear case I found the gears chewed and broken, the teeth on the driving spindle gone and everything more or less damaged.

The cause was never found, to my knowledge, even by experts sent by the company. At another time the outboard bearing on the high-speed spindle showed a slight haze of smoke and I was called to examine it. On touching the bearing with my hand it felt about as usual and the sight-feed oiler was running freely. Picking up an electric hand light, I bent over to examine the open end and was struck on the cheek by a drop of babbitt, while a stream of it poured out of the bearings end. I dismantled the bearing and after cleaning the end of the shaft, placed a new brass in position. Everything started up well and has been running satisfactorily ever since. I was unable to find any cause for this unless the watchman lied about the oiler being clear up to the time I was called.

The governor working loose one day caused the pumps to lose their suction as the turbine would not come up to its speed on starting. It had me guessing for some time before I discovered what was wrong.

These and many other small things that have happened in the last 5 months have made me think there is opportunity for trouble on small turbines as well as on large ones.

This turbine runs day and night, and while its load is steady, it has rather a hard row to hoe and maybe I should not complain if it lays down once in a while.

C. L. MALLERY.

Myerstown, Penn.

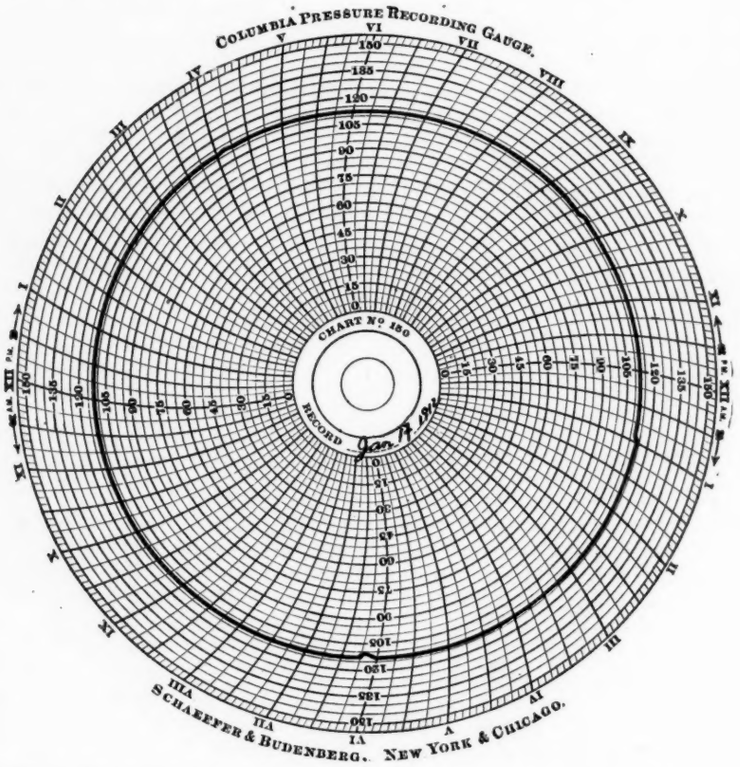
Comments on Pressure Chart

In the Aug. 13 issue, B. M. Seymour shows a recording steam-gage chart and asks for comments on it. I do not think it a very good one as the steam pressure is not uniform but varies over 10 lb. on nearly every firing, which seems to occur about seven times an hour.

Mr. Seymour should fire oftener and in smaller quantities, using the alternate method. Firing one-half of the furnace one time and the other half the next is better for hand firing, and will make less smoke than firing the whole furnace at once, and will keep the pressure more uniform. This method comes as near to automatic stoking as I have been able to get with hand firing. From the amount of coal used I think the boilers are working at about capacity. There may be some cases where automatic stokers will not give as good satisfaction as hand firing, but in many instances where the stokers fail the cause is not in the stoker but in the way in which they are operated.

The accompanying chart was taken during the heavy-load period at a plant using three 200-hp. boilers which frequently carried 100 per cent. overload between 6 a.m. and 4 p.m. and especially from 7 a.m. to 10 a.m., while the buildings were being warmed up.

These boilers were fired by underfeed stokers using forced draft of about 2 in. of water in the air duct, and burning bituminous slack and crushed mine-run coal. The fires are cleaned twice during the 24 hr. One man fires the three boilers, and then sits down one-half the time. The coal is brought in on a small truck and shoveled into the hopper. The dampers in the stack are set at a certain point and only changed as the load varies. The forced draft is controlled by a regulator which operates on one or two pounds variation of pressure. The speed of the fan ranges from 150 to 450 r.p.m. as required.



STEAM CHART FROM PLANT USING MECHANICAL STOKERS AND CARRYING HEAVY OVERLOADS

On this chart the greatest variation of pressure during the 24 hr. was 4 lb., and that was while cleaning fires. No matter how hard the fires are forced there is no smoke except while cleaning fires.

In another plant of which I had charge there were six 250-hp. boilers, all of which were formerly required to keep up the steam pressure. These were hand fired with coal that was bought by the ton and not for what it was worth to us. A new 30x40-in. mill engine was installed, and the boilers thoroughly cleaned. Coal was bought that gave the best results, and not by its looks, name or price per ton. One boiler was taken off the line and held in reserve. Most important, the boiler-room force was reorganized so that better results could be had. The firemen were all foreigners and paid low wages. The pressure was held at 145 lb., with the safety valve set at 150, and although the mill engines started and stopped frequently, the recording steam gage seldom showed a variation of over 10 lb. during the 24 hr. and the safety valves opened not more than three or four times a day. The boilers were fired alternately about every 3 min. using from two to four scoops of coal at a time.

In this plant the firemen did not wait for the steam to drop before firing, but used a pilot light as a guide instead of the steam gage. As the lever on the damper regulator moved on a 2 lb. variation of pressure, I placed a contact on the end of the lever so that when the pressure was below 144 lb., the contact was closed and a red light would show in the boiler room where it could be seen by all. When the pressure came up to 146 lb. and the lever raised to operate the dampers the light went out. The reappearance of the light was a signal to fire one side.

I do not know at present just how much coal was saved by the change, but the output of the mill was increased over 50 per cent. with a small increase in coal consumption, due mostly to good coal and close attention.

J. CASE.

Hyattsville, Md.

What Made the Engine Stop?

In the issue of July 23, Mr. Bullis gave an account of an engine stopping with the throttle and exhaust valve wide open, and asks what the trouble was.

I know of a high-speed engine directly connected to a 100-kw. generator that came to a standstill while about two-thirds loaded, but unlike Mr. Bullis' engine it could be turned by hand shortly afterward. Then the throttle was again opened and the engine gave good service.

Upon examination after the day's run, we found the piston had "frozen" from lack of proper lubrication, and the cylinder scored badly. After the cylinder had been smoothed up and the rings cleaned the engine was again put into commission, and, although it required a lot of oil to keep it quiet, is now running as good as ever.

If Mr. Bullis will look into the cylinder he will very likely find the walls badly scored.

G. B. LONGSTREET.

Somerville, Mass.

Inquiries of General Interest

All Questions Must be Accompanied by Name and Address—Not for Publication

Heat Units per Boiler HP.

What number of heat units transferred per hour constitutes a boiler horsepower? Why do authorities vary from 33,000 heat units upward, and are the differences of importance?

G. B. L.

In deference to the popular application of the term horsepower to boilers, the committee of Judges of the Centennial Exposition, 1876, adopted as a unit of boiler horsepower the evaporation of 30 lb. of water fed at 100 deg. F. into steam at 70 lb. per sq.in. above atmosphere, these conditions being considered to represent the average consumption of steam per horsepower per hour by good non-condensing engines in use at that time. According to steam tables quoted by D. K. Clark, mainly based on Regnault's experiments and formulas, in which a heat unit is taken as the quantity of heat required to raise 1 lb. of water at atmospheric pressure from 32 to 33 deg. F., the latent heat of evaporation of 1 lb. of water at atmospheric pressure and 212 deg. F. is 965.2; and reckoned from 32° F. and atmospheric pressure, the total heat of 1 lb. of steam at 70 lb. pressure above atmospheric pressure (84.7 lb. abs.) is 1177.8 + British heat units. According to this nomenclature, the heat required per hour per boiler horsepower by the Centennial standard is

$$[1177.8 - (100 - 32)] \times 30 = 33{,}294 \text{ } B.t.u.$$

and the heat equivalent from and at 212 deg. would be

$$\frac{33{,}294}{965.2} = 34.494 \text{ } lb. \text{ } of \text{ } water$$

The American Society of Mechanical Engineers' Committee on Boiler Tests, 1899, adopted substantially the same value by recommending the definition of a commercial boiler horsepower as the equivalent evaporation of 34.5 lb. of water per hour from and at 212 deg. F. and this value is generally accepted. According to the tables referred to this is equivalent to 34.5 × 965.2 = 33,299.4 B.t.u. Discrepancies frequently arise from employing 1178 in place of 1177.8 and the use of 966 in place of 965.2. Employing the Marks and Davis steam tables the same evaporation would be represented by 34.5 × 970.4 = 33,478.8 heat units, according to the standard and formulas used in the construction of those tables.

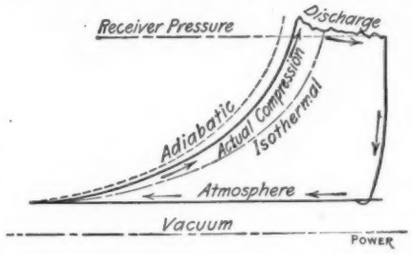
The differences are rarely of importance in an engineering sense, for, although each of the computations are construed as based on the same heat unit, the widest discrepancy would amount to less than 1 per cent.

Air Compressor Diagrams

How does the compression line of an air-compressor diagram compare with that of a theoretical diagram; and why is the discharge line irregular and higher than the receiver pressure?

C. H. B.

In consequence of loss of heat during compression the compression line of an actual diagram will be lower than the theoretical adiabatic line and higher than



the theoretical isothermal line, as illustrated. The discharge line of the actual diagram is irregular on account of vibrations of the discharge and check valves and has to be higher than the receiver pressure to overcome friction of valves, piping and passages employed for conducting the compressed air from the cylinder to the receiver.

Permanent and Electromagnets

What is the difference between a permanent magnet and an electromagnet?

V. F.

A permanent magnet is of hard steel and when once magnetized remains so indefinitely. An electromagnet, on the other hand, is of soft steel or iron and its magnetism is dependent upon the maintenance of a current in the coil surrounding it.

High Duty Pump

What is the difference between a high-duty and a low-duty pump?

D. P.

A high-duty steam pump is one in which provision is made for working the steam expansively—while in ordinary or low-duty pumps the steam follows full stroke.

Increasing Chimney Draft

The force of draft of a chimney 100 ft. high is ⅜ in. of water. How much would the force and amount of draft be increased by increasing the chimney height to 150 ft. with the same size of flue?

J. F. R.

For the same temperature of chimney gases the force of the draft is in direct proportion to the height, and for the increased height of the chimney would be

$$\tfrac{3}{8} \text{ } in. \times {}^{150}/_{100} = \tfrac{9}{16} \text{ } in. \text{ } of \text{ } water.$$

Neglecting a small proportional increase of friction, due to the increased velocity of the gases, the relative velocity and amount of draft would be as the square roots of the heights, viz., as $\sqrt{100}$ to $\sqrt{150}$, or 10 to 12.44, being an increase of 24 to 25 per cent.

Air Pressure and Temperature

What will be the pressure of air if taken at 100 lb. gage pressure and heated to 500 deg. F.? W. C. C.

It is necessary to take the initial temperature into account. When the volume is constant the absolute pressure will vary as the absolute temperature. If the initial temperature were 150 deg. F. the initial absolute temperature would be 150 + 460 = 610 deg. and at 500 deg. F. the absolute temperature would be 500 + 460 = 960 deg. As a gage pressure of 100 lb. = 114.7 lb. absolute, then for an initial temperature of 150 deg. F. raised without change of volume to 500 deg. F. the pressure of the air would become

$$114.7 \times \frac{960}{610} = 180.5 \text{ } lb. \text{ } absolute$$

or

$$180.5 - 14.7 = 165.8 \text{ } lb. \text{ } gage \text{ } pressure$$

Steam Connections for Damper Regulators

Where should the boiler-pressure pipe of a damper regulator be connected?

W. M. M.

The pressure pipe should be connected to the steam space of the boiler whose draft is to be regulated. Connections for diaphragm damper regulators may be placed on the steam connections of water columns, but steam-piston regulators and those which discharge steam should be independently connected with the boiler steam space.

Study Questions

This Week's Questions
Last Week's Answers

(101) A 12-in. ball is in a corner of a room. What must be the diameter of another ball which can touch the first one while both rest on the floor and touch the same walls?

102) How fast must an automobile go to literally "cut circles around" a man walking at 8 miles an hour? Both start from the same place at the same time and the automobile makes a complete circle around the man and meets him again while he is walking in a straight line.

(103) What should be the rim weight of a cast-iron flywheel 15 ft. in diameter, for an 18x36-in. Corliss engine running at 90 r.p.m.?

(104) Steam at 110 lb. gage is admitted throughout the stroke of an 18x30-in. engine, and exhausted at atmospheric pressure. What is the theoretical indicated horsepower if the engine makes 75 r.p.m.?

(105) Steam enters a condenser at 11 lb. abs. Water enters at 53 deg. F. and leaves at 110 deg. F. The condensed steam leaves at 120 deg. F. If the engine uses 26 lb. of steam per horsepower-hour while running at 53 hp., how much condensing water would be required theoretically and how much cooling surface should the condenser have, assuming that the number of heat units transmitted per square foot per degree mean difference of temperature between the steam and water is 192?

Answers to the above will appear in the next issue. Answers to last week's questions follow:

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(96) If the engine were 100 per cent. efficient, the developed horsepower would equal the indicated. When the mechanical efficiency is 90 per cent. only $\frac{90}{100}$ of the indicated horsepower will be available, or $85.6 \times 0.90 = 77.04$ hp.

(97) Let

x = Weight of an ell;
y = Weight of a tee.

Then

$$6x + 7y = 33 \qquad (1)$$

and

$$7x + 6y = 32 \qquad (2)$$

From (1)

$$x = \frac{33 - 7y}{6} \qquad (3)$$

From (2)

$$x = \frac{32 - 6y}{7} \qquad (4)$$

Equating (3) and (4)

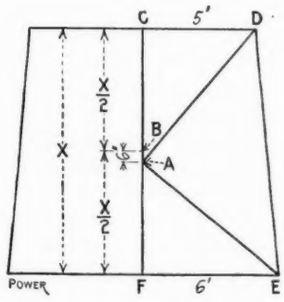
$$\frac{33 - 7y}{6} = \frac{32 - 6y}{7}$$

$$231 - 49y = 192 - 36y$$
$$13y = 39$$
$$y = 3 \text{ lb.}$$

Substituting value of y in (1)

$$6x + 21 = 33$$
$$6x = 12$$
$$x = 2 \text{ lb.}$$

(98) The diagram represents a vertical section of the tank, trapezoidal in form. CF, the vertical axis of the tank, is the altitude of the trapezoid, and must be determined to calculate the volume of the tank.



Lines drawn from A to D and A to E complete two right-angled triangles $ACDA$ and $AEFA$. From the relations of the sides of a triangle

$$\overline{AD}^2 = \overline{AC}^2 + \overline{CD}^2$$

$$\overline{AE}^2 = \overline{AF}^2 + \overline{FE}^2$$

By the conditions of the problem $AD = AE$; therefore

$$\overline{AC}^2 + \overline{CD}^2 = \overline{AF}^2 + \overline{FE}^2 \qquad (1)$$

It was given that

$CD = 5$ ft. (½ the top diameter);
$FE = 6$ ft. (½ the bottom diameter);
$AB = 6$ in. = ½ ft.;
$BC = BF$.

Letting $x = CF$

$$BC = \frac{x}{2}$$

$$BF = \frac{x}{2}$$

and

$$AC = BC + AB = \frac{x}{2} + \frac{1}{2}$$

$$AF = BF - AB = \frac{x}{2} - \frac{1}{2}$$

Substituting in (1)

$$\left(\frac{x}{2} + \frac{1}{2}\right)^2 + 5^2 = \left(\frac{x}{2} - \frac{1}{2}\right)^2 + 6^2$$

$$\frac{x^2}{4} + \frac{2x}{4} + \frac{1}{4} + 25 = \frac{x^2}{4} - \frac{2x}{4} + \frac{1}{4} + 36$$

Reducing

$$x = 11 \text{ ft.}$$

The volume of the tank can now be found by the prismoidal formula

$$V = \frac{h}{6}(A_1 + 4A_m + A_2)$$

where

A_1 A_m and A_2 = Top, middle and bottom areas, respectively;
h = Altitude = 11 ft.

A_1 is the area of a circle 10 ft. in diameter = $0.7854 \times 10^2 = 78.54$ sq.ft. A_2 that of a 12-ft. circle = $0.7854 \times 12^2 = 113.1$ sq.ft. and A_m that of a circle $\frac{10 + 12}{2} = 11$ ft. in diameter = $0.7854 \times 11^2 = 95.033$ *sq.ft.*

Substituting in the formula

$$V = \frac{11}{6}[78.54 + 4(95.033) + 113.1]$$

$$= \frac{11}{6}(78.54 + 380.132 + 113.1) =$$

$$\frac{11}{6} \times 571.772 = 1048.249 \text{ } cu.ft.$$

Since 1 cu.ft. = 7.48 gal., the contents of the tank will be

$$1048.249 \times 7.48 = 7840.9 \text{ } gal.$$

(99) 1 hp. = 746 watts; hence 25 hp. = $25 \times 746 = 18{,}650$ watts. With 85 per cent. power factor this would be equivalent to

$$18{,}650 \div 0.85 = 21{,}941.17$$

apparent watts.

The total power in a three-phase three-wire circuit is

$$E \times I \times \sqrt{3}$$

where E is the voltage between any two wires and I the current in each wire.

$$E \times I \times \sqrt{3} = 21{,}941.17$$

$$I = \frac{21{,}941\ 17}{500 \times 1.73} = 25.37 \text{ } amp.$$

(100) To raise 200,000 lb. up a grade of 50 ft. per 1000 ft. without frictional resistance would require a force of

$\frac{50}{1000}$ or 5% of 200,000 lb. = 10,000 lb.

and if the friction is 2 per cent., then to overcome friction would require:

2% of 200,000 *lb.* = 4000 *lb.*

making a total of 14,000 lb.

Overcoming this resistance at the rate of 1000 ft. per min. would require

$14{,}000 \times 1000 = 14{,}000{,}000$ *ft.-lb., of energy*

which would be exerted at the rate of

$$\frac{14{,}000{,}000}{33{,}000} = 424.24 \text{ } hp.$$

Sun Power Engine

An interesting report concerning irrigation by sun power is made by the British consul at Alexandria, who comments on the arrival from Philadelphia of the Shuman sun-heat absorber, which, he says, was tested and found to be satisfactory. The plant is being erected at Meadi, near Cairo, and will be used to pump water from the Nile to irrigate the surrounding land. Several improvements have been added to reduce the cost of working.

In Egypt, says the U. S. *Consular Daily Report*, both coal and other kinds of fuel are expensive, but plenty of sunshine can be relied upon at all times of the year, so that the experiments with this sun-power plant will be of interest to farmers.

Chemistry's Earning Power*

It may fairly be claimed for chemistry that it is at once the most fundamental and comprehensive of all the sciences. It is directly concerned with the air, the water, the food, the materials upon which we expend our labor, and the things we buy and sell. Chemistry can now determine the suitability of a given water supply for use in boilers or for the requirements of any special line of industry. Furthermore, it supplies the means for correcting undesirable characteristics in a water supply as by use of filtration apparatus, coagulants, and water-softening systems.

That gas is now so cheap is due in large part to the development of the chemical process for making water gas by passing steam through a bed of glowing coals and to the chemical processes for gas enrichment. By the Blau gas system illuminating gas is now produced in liquid form and distributed in steel bottles to isolated consumers like kerosene.

The gas mantle by which the illuminating power of gas is raised from 16 to 60 candles on a consumption of 3½ ft. an hour constitutes one of the most signal triumphs of chemical research.

In the development of electric lighting the chemist has played a part scarcely less important than that of the electrician. The arc light was first shown by Davy between charcoal points and was maintained by the current developed by the action of chemicals in the enormous battery of the Royal Institution. To Faraday we owe the discoveries upon which our modern methods of generating electricity are based. The early history of the incandescent lamp is a chronicle in equal measure of the difficulties of finding a proper material for the filament and those of producing the requisite degree of vacuum in the bulb. Both problems were solved by chemistry which first supplied the carbon filament made by dissolving cellulose, squirting the solution into a thread of the required diameter, drying and carbonizing the thread and thereafter flashing in an atmosphere of hydrocarbon vapor to deposit carbon on the filament precisely where and in exactly what proportion its original inequalities of resistance to the current made necessary. More recently Whitney and other chemists have since given us lamps of an altogether new order of usefulness by employing new materials, as tungsten, for the filament.

The improvements in incandescent lamps in the last 10 years have resulted in the saving of $24,000,000 a year in the cost of lighting as compared with the cost of equal illumination by the older types of lamp.

To the art of illumination Wohler and Willson have contributed the calcium carbide and acetylene; Pintsch and Blau have developed separate systems for the lighting of trains and houses; to Hewitt we owe the mercury lamp, to other inventors the flaming arc, to Nernst the high efficiency lamp and, long before them all, to Bunsen the blue-flame burner utilized by Welsbach and which constitutes the basic element in gas stove.

American manufacturing is in many respects the most intensive in the world. Nowhere else is a plant scrapped so quickly to be replaced by larger, faster and more efficient machines or labor so speeded up by piece work, bonuses, motion studies, gang organization and the other devices of the efficiency engineer. Our manufacturers understand these things, and what they understand they want. They do not understand chemistry, naturally they do not propose to have any chemist teach them their business. This is reflected in the attitude of their subordinates, who, like their masters, cut themselves off from that great coordinated and organized body of knowledge brought together by thousands of highly trained minds through the incessant questioning of nature during a hundred years.

Consider a few concrete examples of the earning power of chemistry. Cylinder oils generally cost about what one is accustomed to pay. Plants which employ a chemist pay from 19 to 27c. Manufacturers who do not need a chemist commonly pay 45c., 65c. or even $1.50 a gallon. There is probably not a large plant in the country in which, if it is not already under chemical control, the lubrication account cannot be cut in two. In the engine room of one large cement plant the average monthly cost for lubricants had been $337. It is now $30. A concern paying 37c. a pound for a special grease now buys on specification for 5½c. and the mill still runs. One company saves $12,000 a year on cutting oils alone; another, $3600 on boiler compounds.

Chemistry points out the only proper way to buy supplies which is on the basis of their industrial efficiency by means of specifications defining the quality desired and rigid tests to make sure that quality is secured.

*Abstracted from a lecture by Arthur D. Little, Boston, Mass.

The plants and business of the George V. Cresson Co. and Morris Engineering Co. have been consolidated under the title Cresson-Morris Co., Philadelphia, Penn. The new officers are P. H. Morris, president; A. S. Morris, vice-president; Gouverneur Cadwalader, secretary and treasurer; Henry G. Morris, consulting engineer; Joseph M. Hewlett, office manager; Charles H. Moyer, general representative. The new company claims that by combining the facilities of both old companies it can insure much better service and extend its field of usefulness.

Over the Spillway

Just Jests, Jabs, Joshes and Jumbles

Well, for the love of peat! The people over to Washington are telling us that peat in this country is produced only in small quantities and used chiefly as fertilizer and chicken food. We were of the opinion that we had peat to burn!

Sir James Donaldson, a braw body frae bonnie Dundee, said at the recent meeting of the British Association for the Advancement of Science, that spellin' is of nae consequence. Spell as ye like, says Jamie. Hoot, mon! 'Tis a peetiful time POWER would hae wi' its readers if some restraint were not put on the editors by the circumspect printer lads. Are ye gang daft, Jamie?

A railroad company has restricted its maximum passenger-train speed to 70 miles an hour. Who said we are speed-crazy?

Thomas A. Edison now rings up on time-card No. 1 at his laboratory in West Orange, N. J. His card for one week registered 95 hr. 44 min. This is not only an endurance test, but it also shows one reason why Mr. Edison is called a "wizard."

A Maryland power company has served the 400 villagers of Conowingo with notice to trek elsewhere. It will build a dam across the Susquehanna at that point and wants the ground. "Dam" is *the* popular word in the vicinage of Conowingo today.

Maine is some prohibitor! Now its adjutant-general prohibits the use of the Portland armory for a power-plant machinery exhibit. Perhaps the Solons of the Pine Tree State were fearful that the power-plant folks might become intoxicated with joy. Evidently, anything with a "smile" flavor is frowned upon in Maine.

On the "Baltic's" second day out from England a crazed stoker committed suicide by jumping overboard. Because a wealthy passenger having bowels of compassion got up a $500 purse for the widow, the daily press raised a great howdy-do over it, saying he "spent more time down in the boiler room than he did with the other passengers." Listen, Agnes! It must be turrible to be a millionaire an' have them reporter guys a-doggin' your every footstep.

Flow of Water through Check Valves

Result of tests to determine the flow of water through check valves under different pressures, and with several sizes of disks and seats.

During a recent discussion upon what takes place while water is passing through a check valve and allied subjects before the Modern Science Club of Brooklyn, some of the work of the committee on tests was demonstrated by James A. Donnelly. The committee had undertaken the investigation of the flow of water through steam traps, having various sizes of seats, as well as through standard check valves, ball check valves, etc. It was the committee's idea that no commercial test of an appliance should be made with but a very short pipe connection upon it, and as all are used with moderate lengths of pipe connected, it would seem as if this might be a reasonable assumption.

The first appliance tested was a standard, direct-lift ¾-in. check valve. The valve disk was first removed and the flow through the orifice and 1 ft. of pipe was obtained to determine the maximum amount of water which could be discharged, or what might be termed 100 per cent. efficiency. The valve disk was then placed in the valve and the test again run. In the same way, two tests were run with 25 ft. of pipe upon the outlet of the valve. The diagram, Fig. 1, gives a good idea of the cutting down of the discharge with this length of pipe. The two upper curves indicate the amount of water discharged through a check valve and 1 ft. of outlet pipe with and without the valve disk.

A comparison of the discharge of water through a ¾-in. check valve with and without the disk and discharging through a 25-ft. length of ¾-in. pipe is also indicated by the curves. At 30 lb. pressure the discharge through the diskless valve was 55.5 lb. of water per minute; with the disk in the valve, 53.5 lb. per minute was discharged. The difference in the amount of water discharging through 1 ft. and 25 ft. of piping at 20 lb. initial pressure is 42 and 45 lb. as against 58¼ and 59¾ lb. respectively. This indicates the result of pipe friction.

The tests with the ¾-in. ball check valve were made with 1-ft. and 25-ft. lengths of pipe attached to the outlet side, both open to the atmosphere. The discharge of water through the long pipe at 40 lb. pressure was 41 lb. per minute; with the short pipe the discharge was 47 lb. of water per minute.

The lower curve indicates the flow of water through a ¾-in. valve having a seat $\frac{11}{32}$ in. in diameter and with a 1¼-in. flat disk covering the seat as shown in the illustration. At 40 lb. pressure 8 lb. of water per minute was discharged through the outlet. With the disk removed, the discharge was 45 lb. per minute, as indicated by the $\frac{11}{32}$-in. orifice curve.

A restricting device of this character was first used for modifying the flow of gas to a burner as early as 1870. An attempt was made to use this principle about 1895 in a reducing valve for water, steam or other fluids. The principle of its operation is the transforming of pressure head existing at the inlet of the valve into velocity head between the disk and seat. The various pressures existing in the valve were tested and calculated as follows:

When 50-lb. gage pressure was used below the seat, a gage pressure of about 1 lb. was registered above the disk. As the disk at this time is held out of contact with the seat, it is obvious that it must be maintained in that position by an equalization of forces or pressures acting in opposite directions.

The area of the 1¼-in. disk, 1.227 sq.in., multiplied by the absolute pressure, 16 lb., gives a total pressure tending to force the disk toward the seat of 19.63 lb. The area of the seat opening, $\frac{11}{32}$ in. in diameter, is 0.0928 sq.in. This, multiplied by the absolute pressure below the seat opening of 65 lb., gives a pressure tending to hold the disk up of 6.03 lb. This, subtracted from the total pressure above the disk, gives a force of 13.6 lb. as being present between the disk and seat and tending to raise it. If this is divided by the difference in area of the seat opening and disk, 1.1342 sq.in., it gives an average pressure between the disk and seat of 12 lb. absolute or about 5.5 in. of vacuum. See Fig. 3.

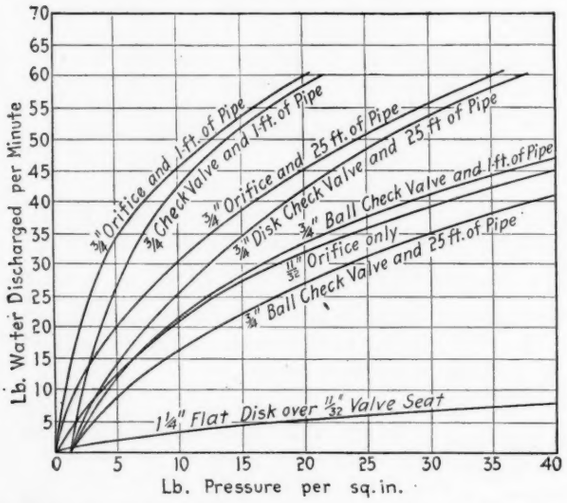

Lb. Water Discharged per Minute
Lb. Pressure per sq.in.
¾" Orifice and 1-ft. of Pipe
¾" Check Valve and 1-ft. of Pipe
¾" Orifice and 25 ft. of Pipe
¾" Disk Check Valve and 25 ft. of Pipe
¾" Ball Check Valve and 1-ft. of Pipe
11/32" Orifice only
¾" Ball Check Valve and 25 ft. of Pipe
1¼" Flat Disk over 11/32" Valve Seat

FIG. 1. DISCHARGE CURVES WITH TWO LENGTHS OF PIPES

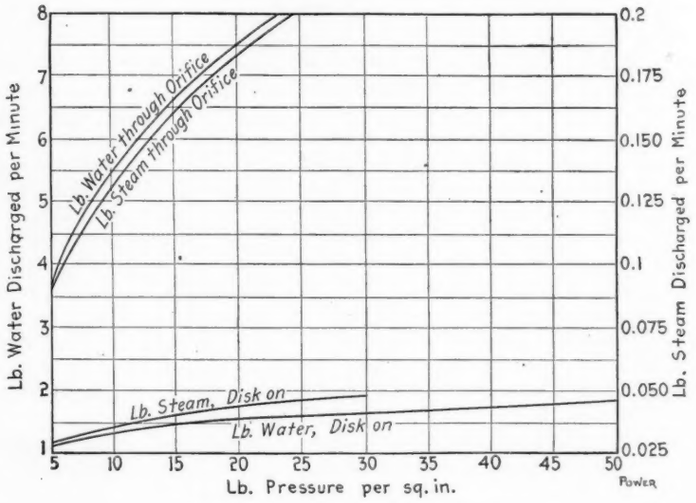


FIG. 2. STEAM AND WATER CURVES

The test of a flat disk steam trap having a ¾-in. connection, seat $\frac{3}{32}$ in. in diameter, and a disk ⅜ in. in diameter, both for steam and water, gave the results shown in the curve of chart Fig. 2.

The capacity of the trap for discharging water was first tested by removing the disk. The disk was then placed on the valve and the same test again run. With the disk in place, the percentage of water passed as compared with that of the orifice without the disk was 31 per cent. at 5 lb., 20 per cent. at 20 lb., and 17 per cent. at 60 lb.

The trap was then tested in the same manner with steam and the result plotted

by using a scale for pounds of steam discharged per minute where the quantities are 1/40 that of the scale for the discharge of water. This was done that a comparison might be made of the relative discharge with steam and water.

With the disk in place, the percentage of steam passed as compared with the orifice without the disk was 33½ per

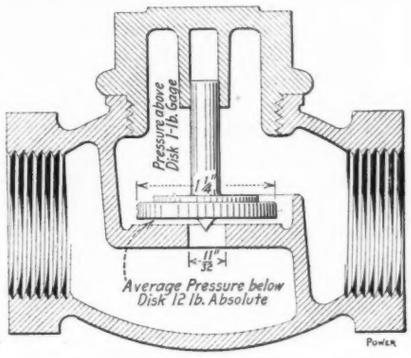


FIG. 3. SECTION OF FLAT DISK TEST VALVE

cent. at 5 lb. and 25 per cent. at 20 lb. pressure. This result shows that the device is more efficient for restricting the passage of water than that of steam. The reason is probably that steam or any fluid which changes in both volume and temperature does not give as high relative velocity for its pressure head as a fluid which, like water, does not change in volume and temperature when flowing through an orifice.

Several tests made upon ball check valves showed that their restriction of

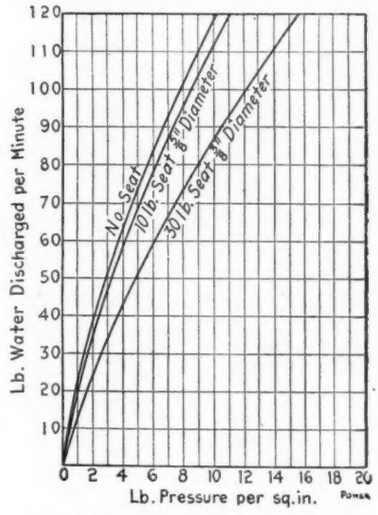


FIG. 4. DISCHARGE OF WATER THROUGH A STEAM TRAP

the passage of water was practically the same as the restriction of the wide, flat disk check valve, last described.

Fig. 4 represented the discharge of water through a ¾-in. steam trap attached to 25 ft. of ¾-in. piping containing eight elbows. At 3 lb. initial pressure the discharge of water through a seat designed to operate at 10 lb. pressure was 47 lb. of water. At 10 lb. initial pressure the discharge was 87 lb. of water, using a 30-lb. seat. The upper curve indicates the flow of water through the same trap with no seat in the discharge valve.

During the test of the ball check valve a severe chattering was set up which varied in intensity with the initial water pressure. Tapping an air cock in the top of the valve cap and releasing the air stopped the noise. With the ball chattering, the discharge through the valve at a pressure of 25 lb. initial pressure was 45.4 lb. of water per minute. With the air removed from the valve cap the discharge, with the same pressure, was about one-half of the flow with the air present. Why the difference in the amount of water discharged?

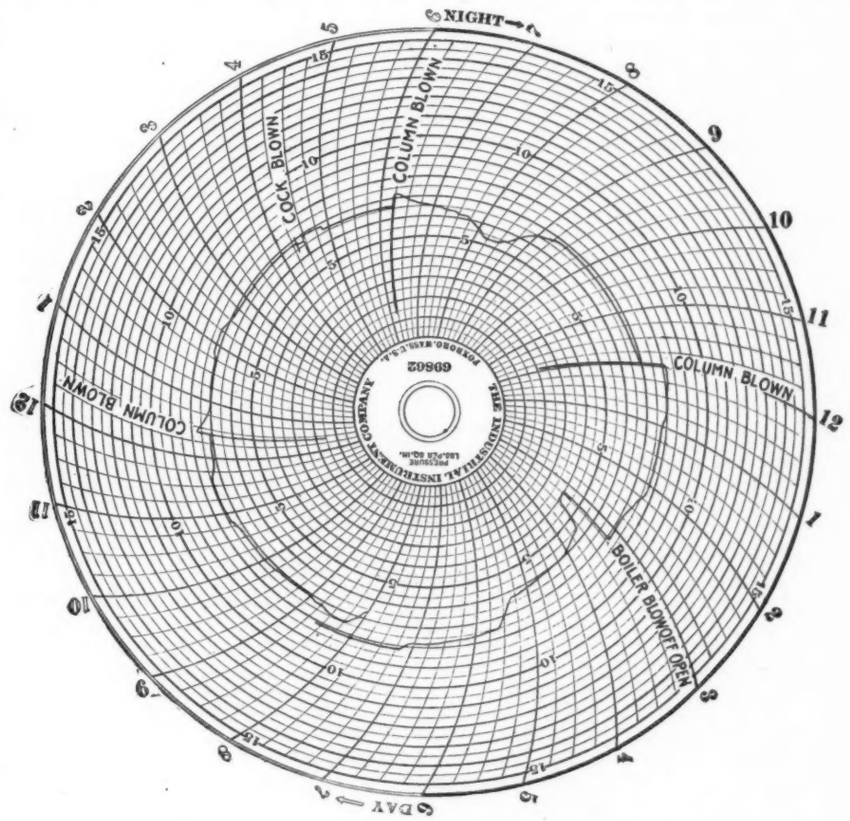
Recording Gage for Boiler Water Level

A pressure-recording gage has ordinarily the pressure of the atmosphere on the outside of the diaphragm or bourdon tube used to measure the pressure, so that the indication of the gage is that of the difference in pressure between the pressure inside the tube and that of the atmosphere. By surrounding the tube with a chamber so that pressure from any source may be maintained on its outside while pressure from another source is admitted to the inside, the gage will indicate the pressure difference.

Such a gage is called a differential-pressure recording gage and is used for various purposes, such as recording the differences in pressure on the up-stream and down-stream sides of calibrated nozzles and venturi tubes, on the static and dynamic orifices of Pitot tubes, etc.

This arrangement offers a solution of the difficulty of making a water-level recorder for steam boilers. The difference in pressure due to the small change in hydrostatic head between the high- and low-water levels is so small in proportion to the steam pressure that any change on a scale which represented the total pressure would be insignificant. By making the steam pressure act upon the outside of the tube and the steam pressure plus the head of the water column on the inside, the whole range of the gage becomes available for the varying pressure due to the varying water level.

The accompanying diagram is a reproduction of a record received from the Industrial Instrument Co., of Foxboro, Mass., made by one of their differential gages used as a water-level recorder on a 125-hp. horizontal return-tubular boiler in a small electric-light plant operating



RECORDING-GAGE CHART FOR BOILER WATER LEVEL

24 hours per day and carrying 90 lb. pressure. The diagram shows, not only the height of water in the glass at any moment of the day or night, but just when the column was blown down and the boiler blown off.

Steam Power Plant Piping Materials

By Wm. F. Fischer

An explanation of the materials used in steam power plant piping and the strengths and weights of the various thicknesses.

Directions are given for determining the proper weight pipe to use under given conditions.

Most of the pipe used in modern steam power plants is known as wrought-steel pipe, claimed by many as more reliable than wrought iron, especially where used to convey superheated steam at high pressure, or where used in expansion bends subject to severe bending strains, vibration, etc., and because mild steel has a higher tensile strength than wrought iron.

Although the tensile strength of new steel pipe exceeds that of wrought-iron pipe, after several years of service, the latter shows a higher tensile strength due to a greater resistance to corrosion and the repeated shocks of vibration than steel pipe.

Expansion and Contraction

For ordinary power-plant purposes the factor of safety of standard weight pipe is so large that the difference between the ultimate tensile strength of the two metals may be ignored as far as the bursting pressure is concerned.

Welded steel pipe has an average ultimate tensile strength of about 50,000 lb. per square inch. Wrought-iron pipe has an average ultimate tensile strength of about 40,000 lb. per square inch.

Wrought-iron pipe costs about 10 per cent. more than steel pipe, and is to be recommended where the pipe is exposed to the weather, buried underground, or where excessive corrosion might be expected, as in drain pipes, feed pipes, blowoff pipes, and those which are not to be kept constantly in service.

Manufacturers Standards

When ordering commercial wrought-iron pipe mild steel pipe will be furnished as a rule. If wrought-iron pipe is required, the specifications should distinctly state it. Mild-steel and wrought-iron pipe are graded as merchant or standard-weight, full-weight, extra-strong and double extra-strong pipe. Full-weight pipe will not vary more than 5 per cent. above or below the weight specified in the manufacturer's catalog.

Merchant or standard weight may vary as much as 6, 8 or even 10 per cent. less than card weight and the thickness will vary accordingly.

Table 1 gives the manufacturer's standard dimensions and card weights of mild-steel and wrought-iron pipe. The outside diameter remains the same for standard, extra-strong and double extra-strong pipe, so that any grade of pipe of the same size may be threaded into any grade of fitting, flange, valve or coupling of the same size.

Columns 3, 4 and 5 give the thickness of the metal in the different grades. The inside diameter of the pipe varies according to the thickness.

Columns 6, 7 and 8 give the nominal weight per foot of length. Unless otherwise ordered, manufacturers will ship standard and full-weight pipe with threaded ends and one wrought-iron coupling to each full length; extra-strong and double extra-strong pipe will be shipped with plain ends, unless otherwise specified.

Generally pipe up to 3-in. size is butt-welded and the larger sizes lap-welded. The standard and full-weight pipe is tested to from 600 lb. in the small sizes to as high as 1500 lb. per square inch in the larger sizes, and extra-strong pipe is tested to considerably higher pressures, depending upon the size. When tested to destruction by the Crane Co., a piece of 10-in. standard-weight wrought-iron pipe burst at 1900 lb. pressure per square inch. A 10-in. standard-weight mild-steel pipe burst at 3000 lb., a 10-in. extra-strong wrought-iron pipe burst at 2700 lb., a 2-in. standard-weight mild-steel pipe burst at 5800 lb., and a 2-in. standard-weight wrought-iron pipe burst at 4500 lb. pressure. None of this pipe burst at the weld, but some distance from it. An 8-in. standard wrought-iron pipe was tested to 2800 lb. without bursting, and an 8-in. standard wrought- or mold-steel pipe was tested to 3200 lb.

From the foregoing there seems to be no reason why pipe heavier than merchant or standard weight should be used for ordinary purposes and pressures up to 200 lb. per square inch. For pressures above this and up to 250 lb. per square inch full-weight pipe should be used. Extra-strong pipe is used for higher pressures, or for lower pressures also, where the pipe is subject to severe shocks, heavy vibration or excessive corrosion. Double extra-strong pipe is approximately twice as heavy as extra-strong pipe and is used mostly on hydraulic work, step-bearing oiling systems, etc., and is frequently subjected to pressures as high as 4000 lb. per square inch. For making up pipe bends no pipe lighter than full-weight should be used.

Large O. D. Pipe

All steel and wrought-iron pipes above 12 in. are specified by their outside diameters and known as O. D. pipe. Thus, a 14-in. pipe 3/8 in. thick will be 14 in. outside diameter and 14 — 3/4 = 13 1/4 in. inside diameter. Large O. D. pipe varies in thickness from 1/4 in. to 3/4 in., depending upon size and service for which it is required.

The terms "merchant pipe," or "standard pipe" should never be applied when ordering pipe larger than 12 in., but the outside diameter and thickness should always be stated in the specifications. When the thickness is not specified manufacturers will generally supply pipe 5/16 or 3/8 in. thick in sizes from 14 to 16 in. inclusively, and 3/8 in. thick in the larger sizes. For threaded or screwed work 1/4-in. metal is too light; 5/16 in. is considered a minimum thickness and 3/8-in. thickness is preferable for good results.

TABLE 1. STANDARD DIMENSIONS OF WROUGHT IRON AND STEEL PIPE, FROM 1 INCH TO 12 INCH INCLUSIVE

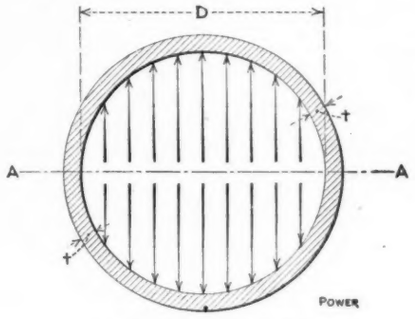
1	2	3	4	5	6	7	8
		Thickness in Inches			Nominal Weight per Foot		
Pipe Size	Outside Diameter Inches	Standard Weight	Extra Strong	Double Extra Strong	Standard Weight	Extra Strong	Double Extra Strong
1	1.315	0.134	0.182	0.364	1.668	2.17	3.65
1¼	1.660	0.140	0.194	0.388	2.244	3.00	5.20
1½	1.900	0.145	0.203	0.406	2.678	3.63	6.40
2	2.375	0.154	0.221	0.442	3.609	5.02	9.02
2½	2.875	0.204	0.280	0.560	5.739	7.67	13.68
3	3.500	0.217	0.304	0.608	7.536	10.25	18.56
*3½	4.000	0.226	0.321	0.642	9.001	12.47	22.75
4	4.500	0.237	0.341	0.682	10.665	14.97	27.48
4½	5.000	0.246	0.360	0.718	12.34	18.22	32.53
5	5.563	0.259	0.375	0.750	14.502	20.54	38.12
6	6.625	0.280	0.437	0.875	18.762	28.58	53.11
*7	7.625	0.301	0.500	0.875	23.271	37.67	62.38
8	8.625	0.322	0.500	0.875	28.177	43.00	71.62
*9	9.625	0.344	0.500	....	33.701	48.25	....
10	10.750	0.366	0.500	....	40.065	54.25	....
12	12.750	0.375	0.500	....	48.985	65.00	....

*Note: 3½-7 and 9 in. pipe are odd sizes not so frequently used for general power plant work as the other sizes. For more complete tables of dimensions see manufacturers catalogs.

The standard thickness and weights of large outside-diameter pipe are given for reference in Table 2.

Bursting Pressure and Factor of Safety

The following rules and examples show the method of calculating the bursting pressure and safe working pressure for pipes of known internal diameter and thickness. A pipe or cylinder, when subjected to internal pressure, is strained equally in all its parts and if rupture occurs it is always in the direction of the length.



Cross-section of Pipe

The illustration is a cross-section of a piece of pipe of unit length. The arrows show the direction of the pressure tending to burst the pipe along the line *AA*, or in the direction of the length. The formula

$$P = \frac{2ts}{D}$$

gives the absolute safe static pressure which may be put upon a pipe in which

P = Internal fluid pressure in pounds per square inch;
D = Inside diameter of pipe in inches;
L = Length of pipe in inches;
t = Thickness of metal in inches;
S = Tensile strength of pipe metal in pounds per square inch.

The total bursting pressure, or the pressure tending to burst the pipe and tear the plates apart along line *AA* equals

$$PDL$$

This bursting pressure is resisted by the stress in the ring of metal composing the pipe, which is

$$2\,tLS$$

Therefore,

$$PDL = 2\,tLS$$

or canceling L from each term of the equation we get

$$PD = 2\,tS$$

and transposing, we get,

$$P = \frac{2ts}{D} \qquad (1)$$

and

$$t = \frac{PD}{2S} \qquad (2)$$

To find the internal pressure necessary to burst a piece of 8-in. standard-weight mild-steel pipe, assuming the ultimate tensile strength of the metal to be 50,000 lb. per square inch we find from Table 1, column 2, that an 8-in. standard pipe is 8.625 in. outside diameter and from column 3 is 0.322 in. thick. The inside diameter is, therefore,
8.625 — (2 × 0.322) = 7.98, *say* 8 *in.* Then substituting in formula 1,

$$P = \frac{2 \times 0.322 \times 50{,}000}{8} = 4025\ lb.\ per\ sq.in.$$

Assuming this pipe to be subject to only 200 lb. internal pressure per square inch the factor of safety would be

$$\frac{4025}{200} = 20.12$$

or $^1/_{20}$ of the bursting pressure.

The thickness of metal required in pipe of 8 in. inside diameter to burst under an internal pressure of 4025 lb. per square inch, assuming the ultimate tensile strength of the pipe material to be 50,000 lb. per square inch, is found by substituting in fomrula 2

$$t = \frac{4025 \times 8}{2 \times 50{,}000} = 0.322\ in.\ or\ \tfrac{5}{16}\ in.$$

To find the unit fiber stress of the pipe material in pounds per square inch, due to the internal fluid pressure; or, in other words, to find to what extent the metal is strained, use the formula

$$f = \frac{PD}{2t}$$

where

f = Unit fiber stress in pipe material in pounds per square inch;
P = Internal fluid pressure in pounds per square inch;
D = Inside diameter of pipe in inches;
t = Thickness of pipe metal in inches.

To find the unit fiber stress in the metal of an 8-in. standard mild-steel pipe of 8 in. inside diameter and 0.322 in. thick, considering the pipe to be subjected to an internal pressure of 200 lb. per square inch, substituting in the formula

$$f = \frac{200 \times 8}{2 \times 0.322} = 2485\ lb.\ per\ square\ inch$$

and

$$\frac{50{,}000}{2485} = 20,\ the\ factor\ of\ safety$$

An average tensile strength of 50,000 lb. for mild-steel or wrought-steel, and 40,000 lb. for wrought-iron pipe is the average for pipe material as adopted by pipe manufacturers.

For steam piping the factor of safety employed should never be less than 6 as there are stresses, due to expansion and contraction, vibration, shocks, due to water-hammer, etc., and there is also the corrosive action of the metal to be taken into account, as corrosion gradually decreases the strength of the pipe metal.

For feed-water mains and similar piping subjected to excessive corrosion, the factor of safety should never be less than 8 and from 10 to 15, or more is desirable. For feed mains, water mains and all pipe subjected to excessive corrosion or pitting, galvanized wrought-iron pipe is preferable to plain black pipe. For all ordinary pressures as carried in the average run of power work the pressure necessary to burst or rupture merchant or standard-weight pipe is so far in excess of the ordinary working pressure that no calculation for strength is necessary.

For hydraulic work, however, where the pressures to be carried are considerably higher than in the average power plant, it is advisable to determine by formula 3 the unit fiber stress of the pipe material, due to the working pressure, and from that find the factor of safety for the given conditions, or the bursting pressure may be calculated from formula 1, and this bursting pressure divided by the working pressure will give the factor of safety for the given conditions

TABLE 2. STANDARD DIMENSIONS AND WEIGHTS OF LARGE O. D. WROUGHT PIPE

Outside Diameter of Pipe Inches	Weight per Foot of Length—Pounds							
	Thickness Metal in Inches							
	$\frac{1}{4}''$	$\frac{5}{16}''$	$\frac{3}{8}''$	$\frac{7}{16}''$	$\frac{1}{2}''$	$\frac{9}{16}''$	$\frac{5}{8}''$	$\frac{3}{4}''$
14	36.75	45.72	54.61	63.42	72.16	80.80	89.36	106.20
15	39.42	49.06	58.62	68.10	77.50	86.81	96.03	114.20
16	42.09	52.40	62.63	72.78	82.85	92.83	102.70	122.20
17	44.76	55.74	66.64	77.46	88.19	98.84	109.40	130.30
18	47.44	59.08	70.65	82.14	93.54	104.80	116.10	138.30
20	52.78	65.76	78.67	91.49	104.20	116.90	129.40	154.30
21	....	69.10	82.68	96.17	109.60	122.90	136.10	162.30
22	....	72.44	86.68	100.80	114.90	128.90	142.80	170.30
24	....	....	94.70	110.20	125.60	140.90	156.20	186.30
26	....	....	102.70	119.50	136.30	152.90	169.50	202.40
28	....	....	110.70	128.90	147.00	165.00	182.90	218.40
30	....	....	....	138.20	157.70	177.00	196.30	234.40

Note: For threaded ends use nothing less than $\frac{5}{16}$-in. thick. It is not advisable to thread pipe above 20 in. O. D.

The bursting of a water turbine on Sept. 13 at Station No. 1 of the Shawinigan Water & Power Co., at Shawinigan Falls, Que., resulted in drowning an employee and flooding the station.

International Union of Steam Engineers Convention

The third biennial convention of the International Union of Steam Engineers was held at the Hotel Ryan, St. Paul, Minn., on Sept. 9 to 14. The first session opened at 10 a.m., Monday, Sept. 9, when V. E. Patnaude, business agent for Local No. 84, St. Paul, introduced Mayor H. P. Keller as the first speaker. The mayor declared that the people of St. Paul were ardent believers in the value of organization.

H. E. Hall, president of the Minnesota State Federation of Labor, spoke briefly of the work of the federation and made a plea for greater coöperation by the rank and file of organized labor. A. L. Rich, president of the Trades and Labor Assembly, of St. Paul, and Collis Lovely, general vice-president of the Boot and Shoe Workers' Union, made brief speeches.

General President Matt Comerford, after a short speech of thanks to the speakers, formally opened the convention and appointed the committee on law. After a partial report of the committee on credentials was adopted, the convention adjourned at 12 noon.

At the afternoon session, President Comerford appointed committees on rules, officers' reports, resolutions, grievance, insurance and on charters. First Vice-President Milton Snellings presided while President Comerford made his official report. The figures for the organizing work done during the past two years showed that the net gain in membership was 4432. During the past term much attention was paid to the Pacific Coast, where an organizer has been in the field almost continuously. The most gratifying results were obtained in Michigan, where one of the general organizers has been at work for more than a year.

In the discussion of legislation for examining and licensing engineers, a system of uniform license laws was urged as beneficial to both the engineer and the general public. The recommendation that firemen and oilers be admitted to the union as apprentice engineers on the principle adopted by the American labor movement of "one trade, one organization," was adopted. The general secretary-treasurer was allowed to have his report printed as the remaining time would not permit its being read. This report showed the organization to be in sound financial condition, having some $31,650 on hand July 31, 1912. During the past two years 85 new charters were issued, 6 locals reorganized, 25 local charters lapsed or dropped and 2 charters revoked.

Other business sessions were held on Tuesday morning and afternoon, Wednesday morning and on Thursday, Friday and Saturday mornings and afternoons. The bulk of the business transacted was routine or local. A matter of general interest was changing the name, the "International Union of Steam Engineers," to "International Union of Steam and Operating Engineers."

The following officers were elected for the present term: Matt Comerford, general president; Milton Snellings, first vice-president; T. J. Roberts, second vice-president; M. Kelly, third vice-president; M. Murphy, fourth vice-president; W. M. Finlay, fifth vice-president; James G. Hannahan, general secretary-treasurer; trustees, Louis Thurber, chairman; M. J. Cassidy, P. J. Horan.

Peoria, Ill., was selected as the next convention city.

Entertainment Program

The elaborate entertainment program provided reflected much credit upon the committee. The ladies' committee of the "Twin Cities" gave an informal reception to the visiting ladies in the hotel parlors on Monday afternoon. On Tuesday afternoon the ladies attended a party at the Empress Theater. On Wednesday afternoon the delegates and guests enjoyed an automobile ride, visiting historic Old Fort Snelling, the Soldiers' Home, Minnehaha Falls, and points of interest in Minneapolis, returning by way of the State Agricultural School, State Fair Grounds, Como Park and the State Capitol. An unfortunate accident marred the complete enjoyment of this trip. In trying to avoid colliding with another automobile, the driver of a delegates' car ran into a sidewalk in Minneapolis. The machine struck a tree and painfully injured M. Mangan, of Chicago. Mr. Mangan was forced to remain several days in the hospital because of a rather serious injury to his neck.

On Thursday evening the delegates and guests attended a ball and banquet at Minnehaha Hall. On Friday, Mrs. J. J. Hannahan entertained the lady guests at her home on West Lynhurst Ave. The ladies were given an automobile ride about the "Twin Cities" on Saturday, and a tea party at the Emporium tea rooms.

Exhibits

The convention committee had invited T. S. F. Hayes, St. Paul representative of the Dearborn Drug & Chemical Works, to arrange for an exhibit in connection with the present convention. After consulting with William P. Lyons, of the Lyons Boiler Works, and F. J. Camitsch, of the Western Supply Co., St. Paul, space was engaged in the Ryan Hotel corridor, and on Aug. 12 invitations to exhibit and have a representative on the ground were extended to about 200 manufacturers and supply houses. Of this number, 31 engaged space and either sent a representative or arranged for a display. The short time allowed prevented a larger number of exhibitors. As it was, the exhibitors' committee was pleased with the results obtained. The following houses had exhibits and representatives in attendance:

Dearborn Drug & Chemical Works, represented by F. F. F. Hayes, E. T. Ward, A. S. Cook; Western Supply Co., F. J. Camitsch; Quaker City Rubber Co., Charles M. Pinchon and J. B. Freye; Lyons Boiler Works, W. P. Lyons; St. Paul Western Coal Co., H. O. Brown and Charles Wanemaker; POWER, A. R. Maujer; Viscosity Oil Co., W. L. Beardsley; R. B. Whitacre & Co., A. E. Elliott; Platt Iron Works, J. F. Gould; Jenkins

DELEGATES AND VISITORS AT THE ST. PAUL CONVENTION, I. U. S. E.

Brothers, J. C. McHugh; North Western Electric Equipment Co., Neal Snyder; U. S. Graphite Co., Charles H. Schenk; W. S. Nott Co., J. H. Vailes; Crane & Ordway, C. L. Olson; Westinghouse Air Brake Co., W. E. Lean; Hawks Price Co., Ben Hawks; Osborne Valve Co., A. H. Breach; St. Paul Electric Co., Charles Horton; Valley Iron Works, Mr. Camron; Rex Oil Co., Paul Swanson; American Huhn Metallic Packing Co., J. J. Schwends; George M. Kenyon, C. L. Smith; Sim D. Rollins & Co., Sim D. Rollins; The Hill Pump Valve Co., William F. Birch; Robinson, Cary & Sands Co., Charles Peters; Lunkenheimer Co., H. A. Burdorf; Plant Rubber Co., Charles Faucett; The Sutherland-Carson Land Co., A. W. Sutherland.

The exhibitors' committee consisted of F. J. Camitsch, chairman; T. S. F. Hayes, secretary-treasurer, and W. P. Lyons.

Employees' Safety Rules

The Minneapolis General Electric Co. recently issued to its employees a carefully prepared booklet of safety rules, including copies of the state labor laws and suggestions by the state commissioner of labor. Each book is numbered and the recipient is held responsible for its safe keeping as well as for familiarity with its provisions.

The first page is a perforated leaf carrying a blank statement that the employee has read and thoroughly understands the rules. Within 10 days after receiving his copy the employee must sign and return this sheet to the office. Besides general operating rules, there are instructions for the use of special safety devices, descriptions of methods of resuscitation from electric shock, etc.

This book is but one of a number of measures to conserve employees' safety recently carried out in Minneapolis. By a recent city ordinance there, all poles carrying 2300 volts or more must be marked with a 3-in. ring of bright red paint just below the lowest crossarm. Each ring must be kept bright.

Refrigeration Exposition for 1913

The Third International Congress of Refrigeration, to be held in Chicago, September, 1913, was brought to this country through the invitation by the President of the United States under authority of the joint resolution of Congress and extended to the delegates in attendance at the meeting held in Vienna in 1910. The wonderful progress made in refrigeration methods should make this the most important congress yet held.

The organization of an association to manage this exposition is now under way and as soon as incorporated, the work will be commenced. The men behind the enterprise have devoted time and energy to securing this congress, and urge that the industries participating in the cold-storage division make all preparations now.

The notice may be accepted as official that the show will be held, and as rapidly as possible the allied interests through their associations and individual organiations will receive communications direct as to its extent and scope.

NEW PUBLICATION

MODERN ILLUMINATION. By Hortsmann and Tousley. Published by Frederick J. Drake & Co., Chicago, 1912. Size, 7x4½ in.; 265 pages, illustrated. Price, $2, net.

This book, by two well known authors on electrical subjects, has been prepared as a ready reference for architects, managers, electricians and such as have occasion to deal with illumination problems in general. Hence only such theory is included as will be readily comprehended by the practical man.

The text is a compilation in logical order of much material which has heretofore been widely scattered and includes chapters on light, the principles of vision, photometry, characteristics of electric illuminants, reflectors, choice of lamps and indirect lighting. A chapter upon "practical considerations" contains many useful suggestions as to the lighting schemes for various types of buildings and the different rooms therein.

Numerous tables are supplied and enough problems are solved to make the text easily comprehensible.

SOCIETY NOTES

Smoke abatement will be the subject of the monthly meeting of the American Society of Mechanical Engineers in New York, at the Engineering Societies Building, 29 West Thirty-ninth St., Tuesday evening, Oct. 8.

The discussion will be opened by George H. Perkins, Lowell, Mass., with a report on the International Smoke Abatement Exhibition and Conference held in London last March and April. Mr. Perkins was the representative of the Lowell Textile School at this conference and informally of the society also.

Authorities from other cities where the problem has been seriously attacked, and engineers and manufacturers generally will take part in the discussion. The meeting is open to the public and all in any way concerned with the smokeless combustion of coal are invited to attend.

From the standpoint of residents generally the importance of reducing the smoke nuisance is obvious, but it is hoped that this meeting, which will be one of the most important on this subject ever held, may bring out a fund of data in substantiation of the contention that reduced smoke can and should mean greater operating economy.

The Central States Water Works Association held its sixteenth annual convention at Detroit, Mich., Sept. 24 to 26.

No. 3 Association, N. A. S. E., Newark, N. J., has moved into its new quarters at 101-103 Market St. The association announces that it will be pleased to receive catalogs, literature, models, etc., of power-plant equipment. All communications should be addressed to C. L. Johnson, 42 Rowland St., Newark, N. J.

The Fourth National Conservation Congress will be in session at Indianapolis, Ind., on Oct. 1 to 4. The vital resources of the country will be discussed in their many important divisions by men prominent in the field. The National Association of State Conservation Commissioners will also meet in special session during the congress.

The following members were appointed delegates to represent the American Society of Heating and Ventilating Engineers at the Fourth National Conservation Congress at Indianapolis, Ind., on Oct. 1 to 4: Samuel R. Lewis, N. L. Patterson and J. H. Davis, Chicago, Ill.; Theodore Weinshank and Joseph G. Hayes, Indianapolis, Ind.

PERSONAL

A. G. White, electrical engineer of the Tri-State Railway & Electric Co., with headquarters at East Liverpool, Ohio, has resigned. It is understood that Mr. White and a number of business men of Toledo, Ohio, will engage in the manufacture of cement in Chicago.

Peter Junkersfeld, of the Commonwealth Edison Co., Chicago, is in Europe. While in England, Mr. Junkersfeld will visit the Heaton works of C. A. Parsons & Co., where that concern is building the new 25,000-kw. turbo-generator for the Fisk St. Station in Chicago.

H. G. D. Nutting, for several years manager and superintendent of the municipal light and water plant at Fort Atkinson, Wis., recently became associated with the Central Illinois Public Service as district superintendent. Mr. Nutting will be succeeded by W. D. Leonard at the Fort Atkinson plant.

Hans C. Specht, for several years electrical engineer with the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Penn., will soon leave America for an indeterminate stay in Germany. While there, Mr. Specht will be associated as chief engineer of construction work with the Norddeutsche Wollkämmerei & Kammgarn Spinnerei, a textile firm near Bremen. Mr. Specht is a member of the American Institute of Electrical Engineers.

Moments with the Ad. Editor

Here's a question for you—

Suppose every advertiser in this paper "cut out" simultaneously and henceforth your copy of Power came to you without any advertising at all, what would be the result?

Would Power be as interesting to you as it is now?

Would it be as valuable?

If there is any engineer who can answer "yes" in these two instances, we would like to know how he spells his name.

We would like to know what new line of work he is contemplating taking up.

You'll admit that Power would not be as interesting or as valuable without its advertising pages.

Then you *are* getting some good out of Power advertising.

Do you realize, too, that whenever you read one of these advertisements you have given an audience to a sure-enough salesman? That is to say, the *properly written* ads are such.

And whenever this salesman persuades you to buy, do you know *exactly* what has transpired in your mind?

'Tis this—the mental law of sale.

Whether you buy a spool of packing, or a 1000 k. w. unit; or what not, it's there.

First this salesman got your *attention*. How? By a catchy headline, by a pertinent question, a direct command, or possibly by an attractive arrangement or layout.

Then it developed an *interest*. This interest properly augmented then changed into *desire* and the desire intensified developed at once into *action*, on your part.

If this salesman carries you successfully through these four steps it contains *all* the elements of good salesmanship.

It has succeeded in getting you to write for something for which a desire was created in your mind.

But that's not the end—The employer of this salesman has more to perform.

He must obtain and maintain your confidence in his goods.

He does this by rendering you a service through these goods.

If he can render you no material service he fails—and this salesman fails on the next visit.

And remember this—no one knows this truth any better than an advertiser in this paper.

No advertiser in Power sees any profit in selling you something without selling you satisfaction and confidence too.

The modern business slogan reads: "He profits most who serves best." It's universal.

Our advertisers are not so narrow or unbusinesslike that they fail to see beyond the passing of the voucher from your hands to theirs.

They know that only reliable products can be continuously advertised.

They know that they themselves must maintain an unquestionable reliability if they are to remain as an advertiser in this paper.

Now then, as you read the advertisements in this issue bear out these thoughts.

Notice the approach of these many salesmen.

Try yourself—and see how many of them get your attention—

How many of them get you interested—how many of them are able to create a desire in your mind to actually *want* their products—and how many of them persuade you to write for a catalog or free samples or further information, etc.

Look upon these advertisements as so many salesmen calling on *you*, and Power will be more interesting. It will be more valuable than you perhaps have realized before.